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USER'S GUIDE FOR A COMPUTER PROGRAM
TO ANALYZE THE LRC 16' TRANSONIC
DYNAMICS TUNNEL CABLE MOUNT SYSTEM

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for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOREWARD

This report is submitted to the NASA Langley Research Center in partial fulfillment of Master Agreement Contract NAS1-10635-9. This contract involves the formulation of a digital computing program to analyze the stability of models mounted on a two-cable mount system used in the LRC 16' transonic dynamics tunnel.

Mr. R. M. Bennett of the NASA Langley Research Center is the technical monitor. Mr. Eugene Baird of the Grumman Aerospace Corporation is the master agreement program manager, and Mr. Paul Barbero of Grumman is the project manager.

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SYMBOLS

a_c	coulomb friction static force
AKR	rear cable spring constant
b	wing span (reference)
\bar{c}	wing chord (reference)
C_D	drag coefficient (stability axis)
CG	referenced to center of gravity
C_l	rolling moment coefficient
C_L	lift coefficient (stability axis)
C_m	pitching moment coefficient
C_{m_p}	rotational damping coefficient
C_n	yawing moment coefficient
CR	referenced to equation reference center
C_x	x force coefficient (body axis)
C_y	side force coefficient
C_z	z force coefficient (body axis)
F_x, F_y, F_z	external forces on model
\bar{g}	acceleration due to gravity
I_{ab}	inertias with respect to axis a, b at the equation reference center
I_{ab}_{CG}	inertias with respect to axis a, b at the center of gravity
K_{A_z}	vertical acceleration feedback gain
K_ϕ	roll rate feedback gain
K_γ	yaw rate feedback gain
K_e	pitch rate feedback gain
m	model mass
N_p	pulley normal force
p, P	model roll rate

q, Q	model pitch rate
\bar{q}	dynamic pressure
r, R	model yaw rate
S	model reference wing area
T	cable tension
T_F	front cable tension
T_R	rear cable tension
v_o	tunnel velocity
W	model weight
M, N, L	external moments on model
x, y, z	displacement coordinates of model
δ, ϵ, γ	angular rotations around x, y and z axis respectively
α	angle of attack
α_{cd}	direction cosine between flying cable c and body axis d
β	angle of sideslip
δ_a	roll control deflection
δ_e	pitch control deflection
δ_r	yaw control deflection
δ_a	roll control deflection
ω	model rotational rates
ζ	tunnel density

Stability derivatives are indicated by subscript notation. For example:

$$C_{L_\alpha} = \partial C_L / \partial \alpha$$

$$C_{n_p} = \partial C_n / \partial (pb/2v_o)$$

(see section 11.1, description of array AERO)

1.0 INTRODUCTION

In accordance with the requirements set forth under NASA Master Agreement NAS1-10635, Development and Implementation of Space Shuttle Structural Dynamics Modeling Technology-Task Order Number 9, Cable Mount System Study for Space Shuttle, the following report is submitted.

Contained in this report is a discussion of the theoretical derivation of the set of equations applicable to modeling the dynamic characteristics of aeroelastically-scaled models 'flown' on the two-cable mount system in the Langley Research Center 16' transonic dynamics tunnel. Also contained herein is a description of the computer program provided for the analysis.

The program will calculate model trim conditions as well as 3 DOF longitudinal and lateral/directional dynamic conditions for various flying cable and snubber cable configurations. Sample input and output is contained in Appendix B and C.

2.0 GENERAL PROGRAM DESCRIPTION

The digital computer program described in this report is used to analyze the rigid body stability and trim characteristics of models mounted on a 'two-cable mount system' presently used in the Langley Research Center 16' Transonic Dynamics Tunnel. The program is so structured as to allow model, tunnel and cable system parameters to be varied independently in order that their effects on model stability can be analyzed.

All program options, theoretical derivations, and data input formats will be explained in the body of this report. The following items are of special interest and will be explained in detail in the report:

- The trim routine will predict model angle of attack, pitch control deflection and all cable tensions and angles for any tunnel condition of interest to the investigator.
- Stability analysis is accomplished using 2 sets of 3 DOF uncoupled longitudinal and lateral/directional perturbation equations modeling both model aerodynamic effects and cable effects.
- Included in the stability analysis is the ability to investigate the effects of automatic stabilization using model stability augmentation. The general feedback loops provided allow stabilization using pitch, roll and yaw rate feedbacks to yaw, pitch and roll moment generators in the model.
- A root locus feature is built into the program allowing for automatic variation of any input parameter, producing trim variations plus a locus of roots for the longitudinal and/or lateral/directional dynamics.
- Four general cable configurations are included in the analysis: front and rear cables vertical, front and rear cables horizontal, front cable vertical and rear cable horizontal, front cable horizontal and rear cable vertical.

- The effects of both snubbed and unsnubbed snubbers on trim and stability have been included. The general snubber arrangement is a double 'V' shown in Figure 11.3. However, proper selection of input data will convert the snubber model into any snubber configuration presently envisioned.
- Provisions have been made to include the effects of one additional cable attached anywhere on the model.
- All aerodynamic data for the model is input in stability axis as 'point data' at a given mach number or as 'table data' where all coefficients are input across the mach number range in interest.
- All cable tie-down locations and model position are input in tunnel coordinates (station, water line, butt line).
- Normal program output includes the trim condition, the roots of the characteristic equations (longitudinal and/or lateral/directional), damped natural frequency and damping ratio for each pair of complex roots and the time to half amplitude for real roots. Additional program output, as a user option, is included for debugging purposes.

2.1 MAJOR PROGRAM SUBROUTINES

A general flow chart of the program is shown in Figure 2.1. The following comments are made in reference to that chart.

All input data for the initial case is read in first (input format described in Section 11). If table data is to be used, it must be read in on the first pass. If root locus is to be used, the proper value of the parameter to be varied is calculated in subroutine RUTLOC. The next step is to transform the input inertia and aerodynamic data to the equation reference axis in subroutine TRAN1 (Section 3.1 and 3.2). The model is then trimmed in subroutine TRIM described in Section 4.0. After completing the trim, the aero data is transformed to body axis in subroutine TRANS described in Section 3.3. Depending on the option selected by the user

either longitudinal or lateral/directional or both stability calculations are made. These calculations are contained in subroutines LONG and LAT which are discussed in Sections 6.0 and 7.0. Upon returning from these subroutines, the root locus routine is entered if a parameter variation is in progress or a new case is initiated. Input data for a new case is discussed in Section 11.0.

The subroutines formulated to handle snubber effects (SNTRM, LONGSN, LATSN) are called from within the TRIM, LONG and LAT routines and are discussed in Section 8.0.

A description of the three main subprograms, TRIM, LONG, LAT, and their supporting subprograms are presented in Sections 4 , 6, and 7 respectively. The format used is a brief description of the purpose, the theory, some pertinent equations and a functional flow diagram for each subroutine. An exception to this approach is the theoretical development of the perturbation equations and the cable influence coefficient matrix. The development of the theory and equations in generalized form are presented in Section 5.

The particular applications of these generalized equations to the longitudinal and lateral directional analysis are then discussed in Sections 6 and 7 respectively.

The axis system used throughout the study is a conventional right-handed body axis fixed to the model with the origin at a point called the center of reference (cr). The positive x axis points forward out the nose of the model and the positive y axis is out the right wing. Figure 2.2 shows the axis system and a nomenclature of the various cable constraints.

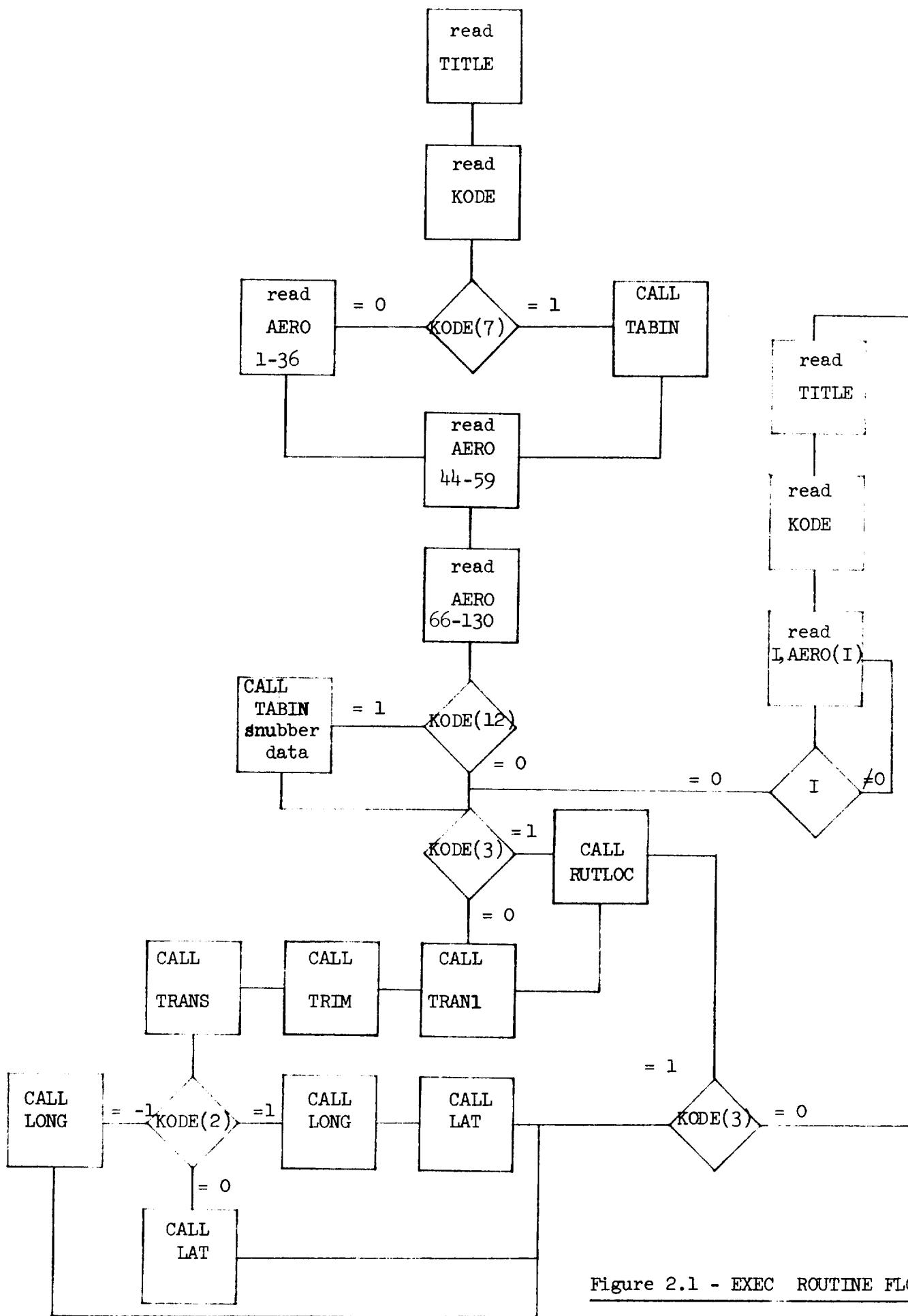
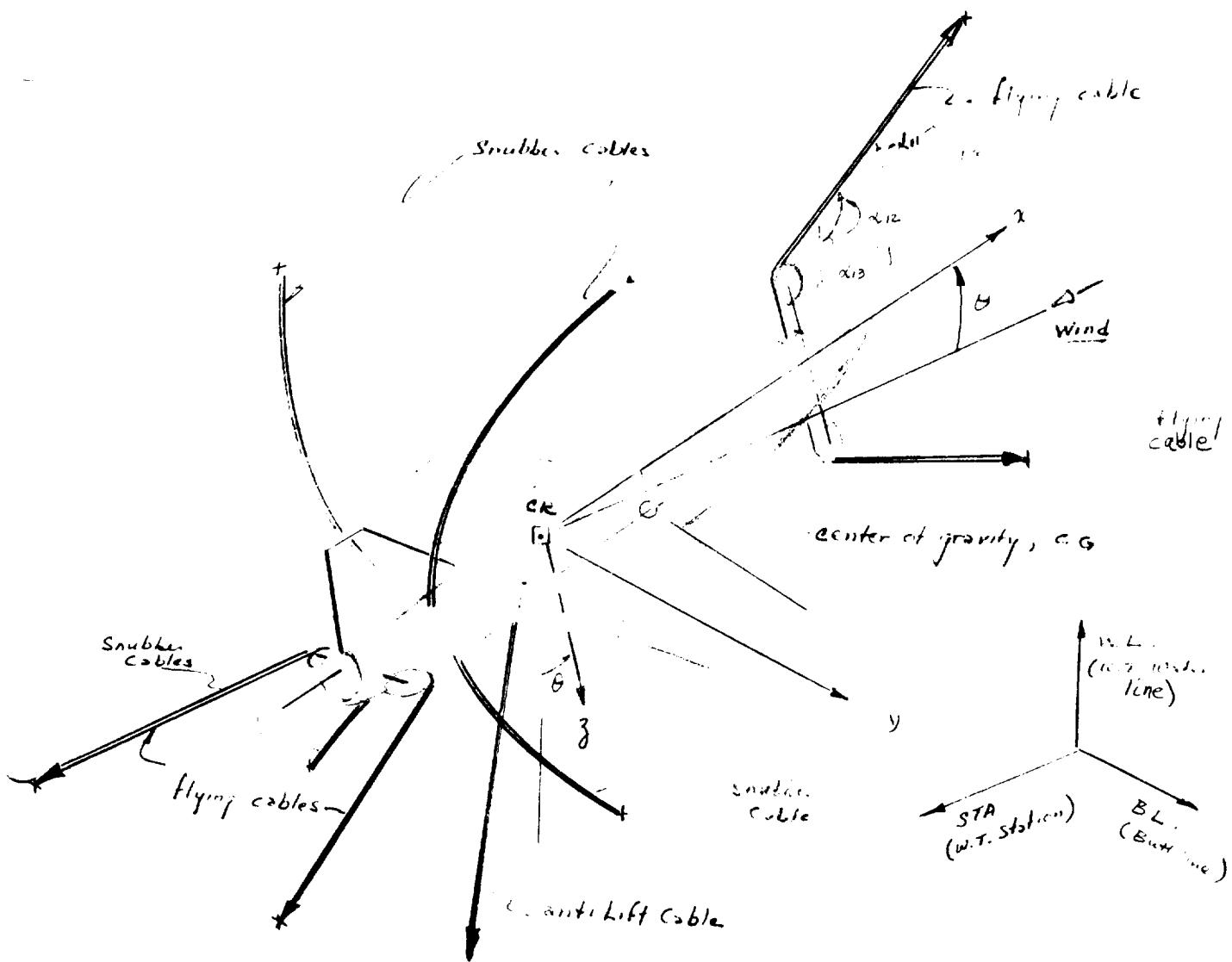


Figure 2.1 - EXEC ROUTINE FLOW CHART



STA, WL, BL - wind tunnel coordinates ~ stations (inches), water line (inches), butt line(inches)

x, y, z - body axis - fixed to the body

α (IC, J) - direction cosine angles, IC defines the cable and J defines the axis. e.g. α_{13} is the direction cosine angle from the z axis to the number 1 cable.

cr - origin of the body axis system, center of reference

C.G. - center of gravity

FIG. 2.2: AXIS AND CABLE DEFINITION

3.0 INERTIA AND AERODYNAMIC DERIVATIVE TRANSFORMATIONS

The program provides for general placement of the model mass center of gravity and the aerodynamic reference point. All force and moment equations have been written around the equation reference center which is located in terms of tunnel coordinates (STACR, WLCR, BLCR). All other reference points (center of gravity and aerodynamic reference) and pulley positions are located with respect to the reference center.

Since all equations are written with respect to the reference center, the inertias and aerodynamic data must be transformed to this center. This is done in subroutine TRAN1.

In addition to a reference center transformation, the aerodynamic derivatives must be transformed from stability to body axis. This is accomplished in subroutine TRANS.

3.1 INERTIA TRANSFORMATION

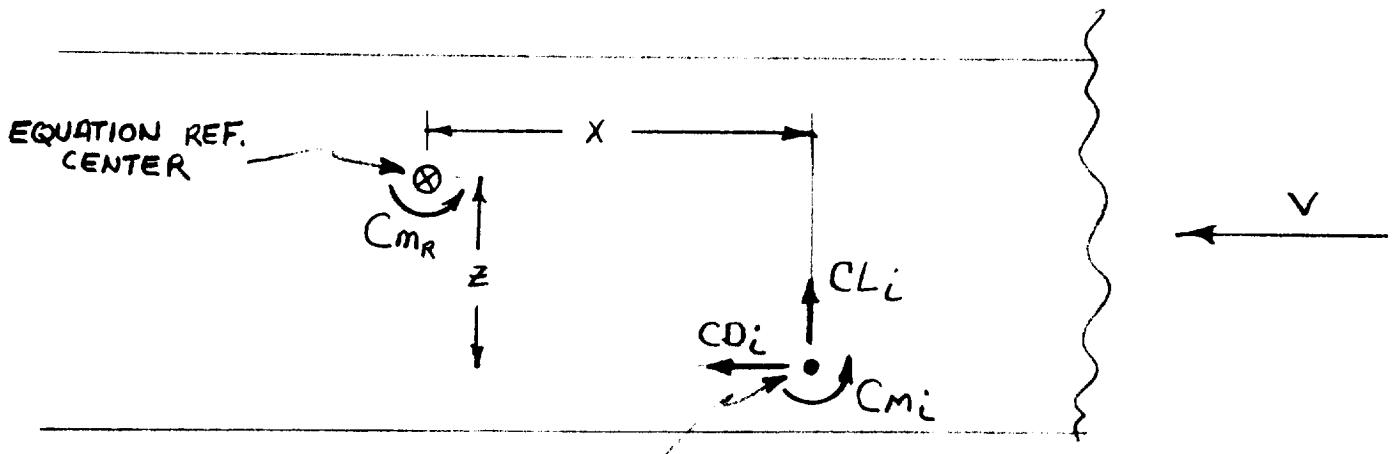
The classic inertia transformations, assuming constant model density, are used to transform mass moment of inertias from the center of gravity (inertias are input as body axis values at the center of gravity) to the equation reference center. The axis systems at the center of gravity and the equation reference center are parallel (both lie along the x-body axis) requiring only a translational transformation. It is also assumed that there is no lateral displacement between the center of gravity and the equation reference center. The resulting equations shown below are modeled in subroutine TRAN1 (Figure 3.1).

$$I_{xx} = I_{xx}_{C.G.} + x^2 m \quad I_{zz} = I_{zz}_{C.G.} + z^2 m$$

$$I_{yy} = I_{yy}_{C.G.} + (x^2 + z^2)m \quad I_{xz} = I_{xz}_{C.G.} - xzm$$

3.2 AERODYNAMIC REFERENCE TRANSFORMATION (Translation)

All aerodynamic moment effects must be transformed to the reference center. The following general theory is used in subroutine TRAN1 to accomplish the transformation.



AERODYNAMIC REF. CENTER

Referring to the above figure:

$$C_{mR} = C_{mi} - \frac{z}{c} CD_i + \frac{x}{c} CL_i$$

A similar situation exists for lateral and directional moment derivatives.

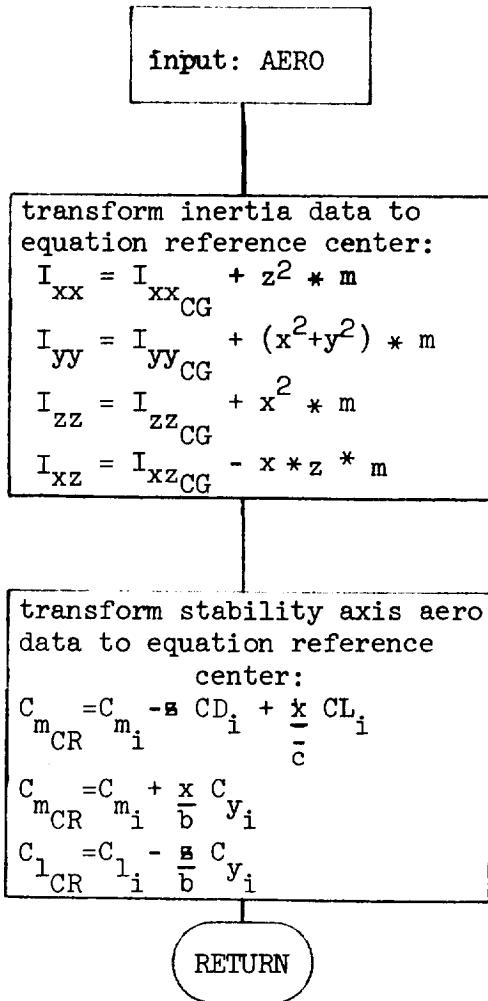
$$C_{nR} = C_{ni} + \frac{x}{b} Cy_i$$

$$C_{lR} = C_{li} - \frac{z}{b} Cy_i$$

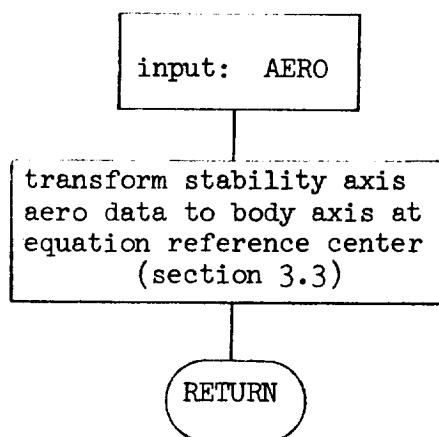
The force derivatives are not effected by a translational shift in axis systems.

3.3 AERODYNAMIC TRANSFORMATION FROM STABILITY TO BODY AXIS (Rotational)

Once the aero data is referenced to the reference center it is then transformed from the stability axis input form to the body axis form necessary for stability calculations. This is accomplished in subroutine TRANS. The transformation equations were taken directly from 'Aircraft Motion Analysis' by Thelander, pgs. 57-58. A flow chart of subroutine TRANS is shown in Figure 3.1.



SUBROUTINE TRAN1



SUBROUTINE TRANS

FIGURE 3.1 - FLOW CHART - TRAN1 AND TRANS

4.0 TRIM ANALYSIS

4.1 Subroutine TRIM

The function of this subprogram is to determine the vehicle trim attitude for a given initial rear cable tension, T_{Ro} . The outputs of the program are the trim attitude, θ , trim elevator deflection, δ_e , and the geometry and tensions of the flying and antilift cable system. The model may be trimmed at any water line and station specified. The equation reference center (STACR, WLCR) is used to position the model in the tunnel.

The subprogram defines trim as the point where the following three requirements on the longitudinal equations of motion are satisfied:

$$\begin{aligned} a_z &= \frac{1}{m} \sum F_z = 0 \\ a_x &= \frac{1}{m} \sum F_x = 0 \\ \ddot{\theta} &= \frac{1}{I_y} \sum M_y = 0 \end{aligned} \quad (4.1 - 1)$$

The variables in this set of equations are θ , δ_e and T_F , the front cable tension. The T_F is a variable because the front cable is fixed in length and the tension must necessarily adjust to satisfy the constraint.

A numerical iterative technique is used to trim the system of cable and model forces. The procedure is based on the following formulation for convergence.

The forces and moments of equation 4.1-1 are expanded using the Taylor's expansion:

$$\begin{aligned} \sum F_z &= F_{zo} + \frac{\partial F_z}{\partial \theta} \Delta \theta + \frac{\partial F_z}{\partial \delta_e} \Delta \delta_e + \frac{\partial F_z}{\partial T_F} \Delta T_F \\ \sum F_x &= F_{xo} + \frac{\partial F_x}{\partial \theta} \Delta \theta + \frac{\partial F_x}{\partial \delta_e} \Delta \delta_e + \frac{\partial F_x}{\partial T_F} \Delta T_F \\ \sum M_y &= M_{yo} + \frac{\partial M_y}{\partial \theta} \Delta \theta + \frac{\partial M_y}{\partial \delta_e} \Delta \delta_e + \frac{\partial M_y}{\partial T_F} \Delta T_F \end{aligned} \quad (4.1-2)$$

Equation 4.1-2 must be equated to zero to satisfy trim.

$$\begin{bmatrix} \frac{\partial F_z}{\partial \alpha} & \frac{\partial F_z}{\partial \delta_e} & \frac{\partial F_z}{\partial T_F} \\ \frac{\partial F_x}{\partial \alpha} & \frac{\partial F_x}{\partial \delta_e} & \frac{\partial F_x}{\partial T_F} \\ \frac{\partial M_y}{\partial \alpha} & \frac{\partial M_y}{\partial \delta_e} & \frac{\partial M_y}{\partial T_F} \end{bmatrix} \begin{Bmatrix} \Delta \theta \\ \Delta \delta_e \\ \Delta T_F \end{Bmatrix} = \begin{bmatrix} A \end{bmatrix} \begin{Bmatrix} \Delta \theta \\ \Delta \delta_e \\ \Delta T_F \end{Bmatrix} = \begin{Bmatrix} -F_{zo} \\ -F_{xo} \\ -M_{yo} \end{Bmatrix} \quad (4.1-3)$$

Inverting matrix A will define the required incremental change to the variables θ , δ_e , and T_F to satisfy trim. i.e.

$$\begin{Bmatrix} \Delta \theta \\ \Delta \delta_e \\ \Delta T_F \end{Bmatrix} = \begin{bmatrix} A \end{bmatrix}^{-1} \begin{Bmatrix} -F_{zo} \\ -F_{xo} \\ -M_{yo} \end{Bmatrix} \quad (4.1-4)$$

The logic in the TRIM subprogram, shown in Figure 4.1, is to compute the initial forces and moments (F_{zo} , F_{xo} , M_{yo}), and determine whether the trim requirement, is satisfied.

If not, the program computes the set of partials in eq. 4.1-3, inverts the matrix A and determines the increments $\Delta \theta$, $\Delta \delta_e$, and ΔT_F . The variables are modified and the forces and moments recomputed.

The Model is assumed to remain stationary in translation during the trim procedure. This assumption violates the constant front cable length constraint, however, the translation associated with attitude changes is negligible relative to the overall front cable length.

If the trim requirement has not been satisfied after 100 iteration cycles, the TRIM subprogram will print out a note to this effect and the last set of θ , δ_e and T_F is assumed in the continuation of the program.

4.2 Subroutine EQU

This subprogram is called by the subroutine TRIM. Its function is to generate the longitudinal forces and moments. Each time this routine is called, it establishes the cable geometry, then computes and sums the force and moment contributions due to aerodynamics, vehicle weight and the system of cables.

The input to this subprogram are the variables θ , δ_e and T_F . The basic equations are:

$$\begin{aligned}\Sigma F_z &= F_{z_{\text{aero}}} + F_{z_{\text{front cable}}} + F_{z_{\text{rear cable}}} \\ &\quad + F_{z_{\text{anti-lift cable}}} + F_{z_{\text{snubber}}} + W * \cos \theta \\ \Sigma F_x &= F_{x_{\text{aero}}} + F_{x_{\text{front cable}}} + F_{x_{\text{rear cable}}} \\ &\quad + F_{x_{\text{anti-lift cable}}} + F_{x_{\text{snubber}}} - W * \sin \theta \\ \Sigma M_y &= M_{y_{\text{aero}}} + M_{y_{\text{front cable}}} + M_{y_{\text{rear cable}}} \\ &\quad + M_{y_{\text{anti-lift cable}}} + M_{y_{\text{snubber}}} + M_{y_{\text{wgt}}}\end{aligned}\tag{4.2-1}$$

The contribution, $M_{y_{\text{wgt}}}$, shown here is a necessary term since the moments are taken about a point other than the center of gravity location.

The aerodynamic forces and moment are determined as follow:

$$\begin{aligned}\text{Lift} &= L = qS(C_{L_0} + C_{L_\alpha} \theta + C_{L_{\delta_e}} \delta_e) \\ \text{Drag} &= D = qS(C_{D_0} + C_{D_\alpha} \theta + C_{D_{\delta_e}} \delta_e) \\ F_{z_{\text{aero}}} &= -(L \cos \theta + D \sin \theta) \\ F_{x_{\text{aero}}} &= -(D \cos \theta - L \sin \theta) \\ M_{y_{\text{aero}}} &= qS\bar{c}(C_{m_0} + C_{m_\alpha} \theta + C_{m_{\delta_e}} \delta_e)\end{aligned}\tag{4.2-2}$$

The anti-lift cable forces and moments are determined by computing the forces in the wind tunnel axis (an axis aligned with the wind tunnel) and then transforming them to the rotated body axis. Along the wind tunnel axis, the F_{xt} and F_{zt} are computed as follows:

$$F_{zt} = FZLTT = TLFT * \cos \alpha_{ZWT} \quad (4.2-3.1)$$

$$F_{xt} = FXLTT = TLFT * \cos \alpha_{XWT}$$

where α_{WT} are direction cosine with respect to the wind axis and TLFT is the anti-lift cable tension force defined by the equation:

$$TLFT = TLFT_0 + AKLFT (\ell - \ell_0) \quad (4.2-3.2)$$

AKLFT here is the spring constant, TLFT₀ is the initial tension corresponding to initial cable length, ℓ_0 . Converting these forces to the body axis we have:

$$\begin{aligned} F_x &= F_{xt} \cos \theta - F_{zt} \sin \theta \\ F_z &= F_{zt} \cos \theta - F_{xt} \sin \theta \end{aligned} \quad (4.2-4.1)$$

The anti-lift cable moment is easily obtained since the attachment point relative to the center of reference is known (ALTX, ALTZ). Thus:

$$M_y = F_x * ALTZ - F_z * ALTX \quad (4.2-4.2)$$

The flying cable forces and moments along the body axis are directly computed since the direction cosines between each cable and the body axis were computed in subprograms FPLYV and RPLYH.

Thus:

$$F_{X_F} = T_F (\cos \alpha_{11} + \cos \alpha_{21})$$

$$F_{Z_F} = T_F (\cos \alpha_{13} + \cos \alpha_{23}) \quad (4.2-5.1)$$

$$F_{X_R} = T_R (\cos \alpha_{31} + \cos \alpha_{41})$$

$$F_{Z_R} = T_R (\cos \alpha_{33} + \cos \alpha_{43})$$

The subscripts of the direction cosine refer to the cable and the axis in question. The two front flying cables are

designated as 1 and 2 and the two aft flying cables are designated as 3 and 4. The body axis x , y , z is referred to numerically as 1, 2, and 3. Thus $\cos \alpha_{13}$ is the direction cosine of the number one front cable with respect to the z -body axis. The rear tension force, T_R , is defined by the following equation.

$$T_R = T_{Ro} + AKR (\ell_R - \ell_{Ro}) \quad (4.2-5.2)$$

where T_{Ro} is the initial cable tension corresponding to ℓ_{Ro} , ℓ_{Ro} being the summation of the initial lengths of cables 3 and 4. AKR and ℓ_R are respectively the rear cable spring constant and the instantaneous summed cable lengths of cables 3 and 4.

A derivation of the generalized cable force and moment is presented in Section 5.4.

The flying cable moments are obtained via the following equation:

$$M_{cable} = \sum_{i=1}^4 \bar{x}_i * \bar{F}_i \quad (4.2-6)$$

where \bar{x}_i corresponds to the moment arm from the center of rotation to the point of action of the force \bar{F} . The components of \bar{x}_i are computed in subroutines FPLYV and RPLYH.

Figure 4.2 presents a functional flow diagram of the subroutine EQU.

4.3 SUBROUTINE FPLYV

The function of this subroutine is to compute the geometry of a set of vertically configured flying cables.

The inputs to this program are:

1. The location of the cable attachment points to the wind tunnel wall
2. The location of the vehicle in the tunnel
3. The vehicle attitude
4. The pulley size
5. The pulley location on the model

The outputs of this program are the following geometric information for the upper and lower cables:

1. A set of direction cosine angles defining the cable orientation in space relative to the body axis (noted as ADC in the program)
2. A set of coordinates locating the point of action of the cable tension force (noted as ARM in the program)
3. The cable length (noted as XLGTH in the program)

Figure 4.3 defines the geometric nomenclature and some of the equations in the subroutine. The equations show the derivation for the cable length and the angle BETAU for the upper cable. Similar computation will define the length and the angle BETAL of the lower cable. Direction cosine angles of each of these cables can be derived from the angles BETAU, BETAL and the vehicle attitude θ . The coordinates of the point of action are also readily computed. The equations for the upper front cable are presented as an example.

Direction Cosines:

$$\begin{aligned}\alpha_{1x} &= \text{ADC}(1,1) = -\beta_u + \theta \\ \alpha_{1y} &= \text{ADC}(1,2) = \pi/2 \\ \alpha_{1z} &= \text{ADC}(1,3) = \pi/2 - \alpha_{1x}\end{aligned}\quad (4.3-1)$$

Point of Action:

$$\begin{aligned}x_p &= \text{ARM}(1,1) = EP - RAD * \sin \alpha_{1x} \\ y_p &= \text{ARM}(1,2) = 0 \\ z_p &= \text{ARM}(1,3) = HUU + RAD * \cos \alpha_{1x}\end{aligned}\quad (4.3-2)$$

A functional flow diagram of this subroutine is presented in Figure 4.4.

SUBROUTINE RPLYH

The purpose of this subroutine is to define the geometry of a set of horizontally configured flying cables.

The inputs required for this subroutine are:

1. The location of the cable attachment points to the wind tunnel wall
2. The location of the model in the tunnel
3. The attitude of the model
4. The pulley size
5. The pulley location on the model

The output of this program is the following geometric information for each of the port and starboard flying cables.

1. A set of direction cosine angles defining the cable orientation with respect to the model body axis (noted as ADC in the program)
2. A set of coordinates locating the cable force point of action (noted as ARM in the program)
3. The cable length (noted as XLGTH)

Figure 4.5 defines the geometric nomenclature used in this subroutine. Figure 4.6 presents a functional flow chart of the program logic.

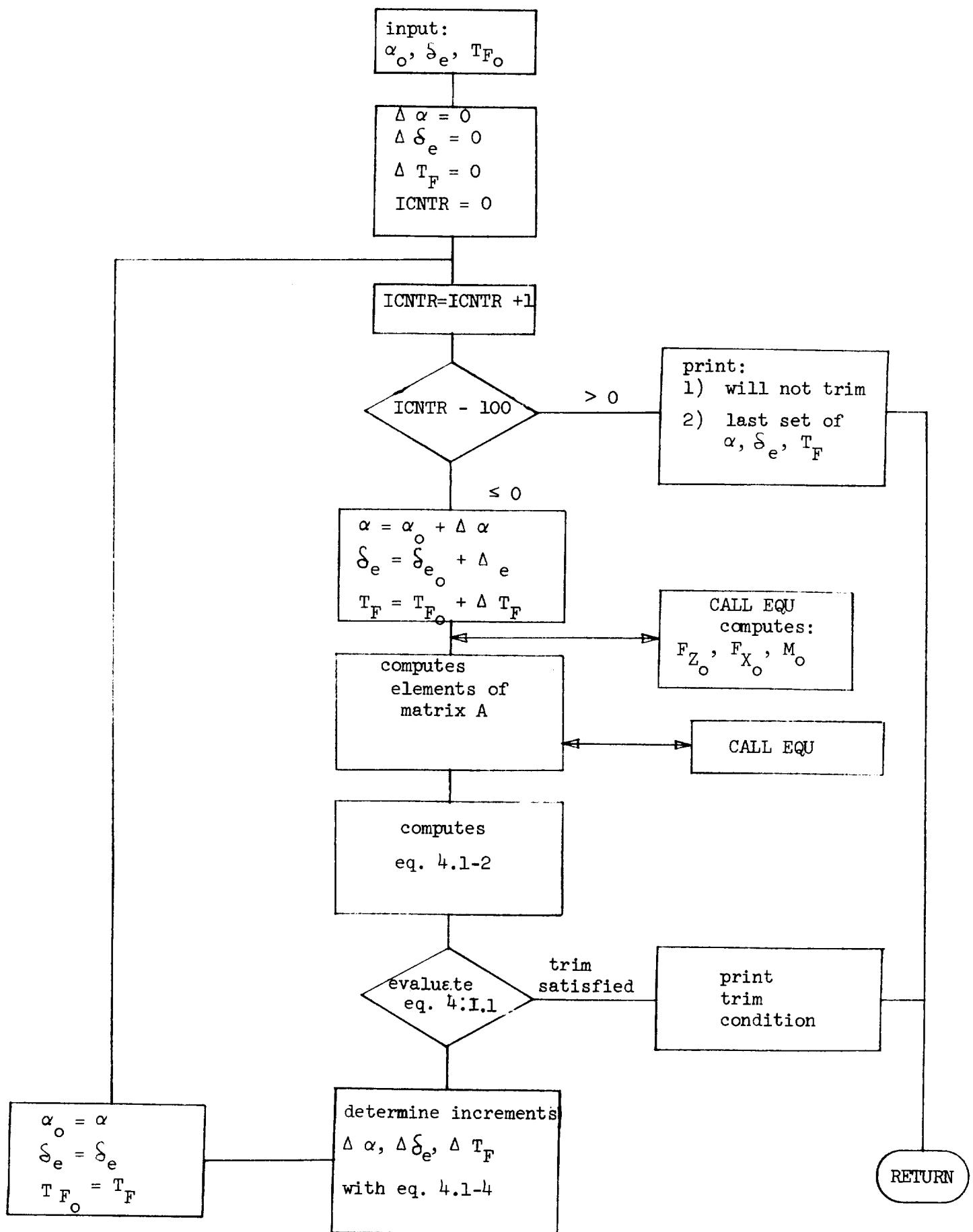


FIGURE 4.1 - FLOW CHART - SUBROUTINE TRIM

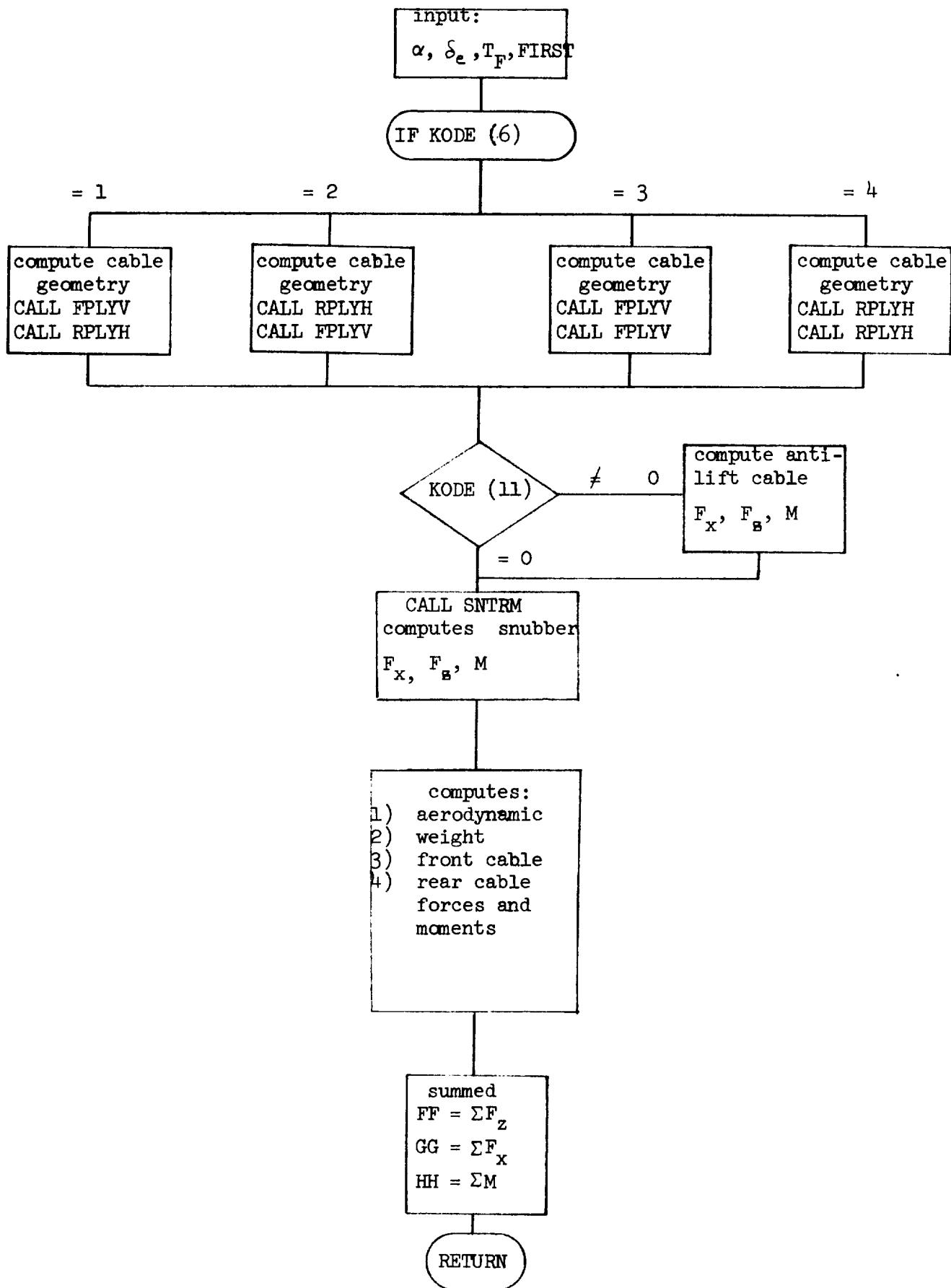


FIGURE 4.2 - FLOW CHART - SUBROUTINE EQU

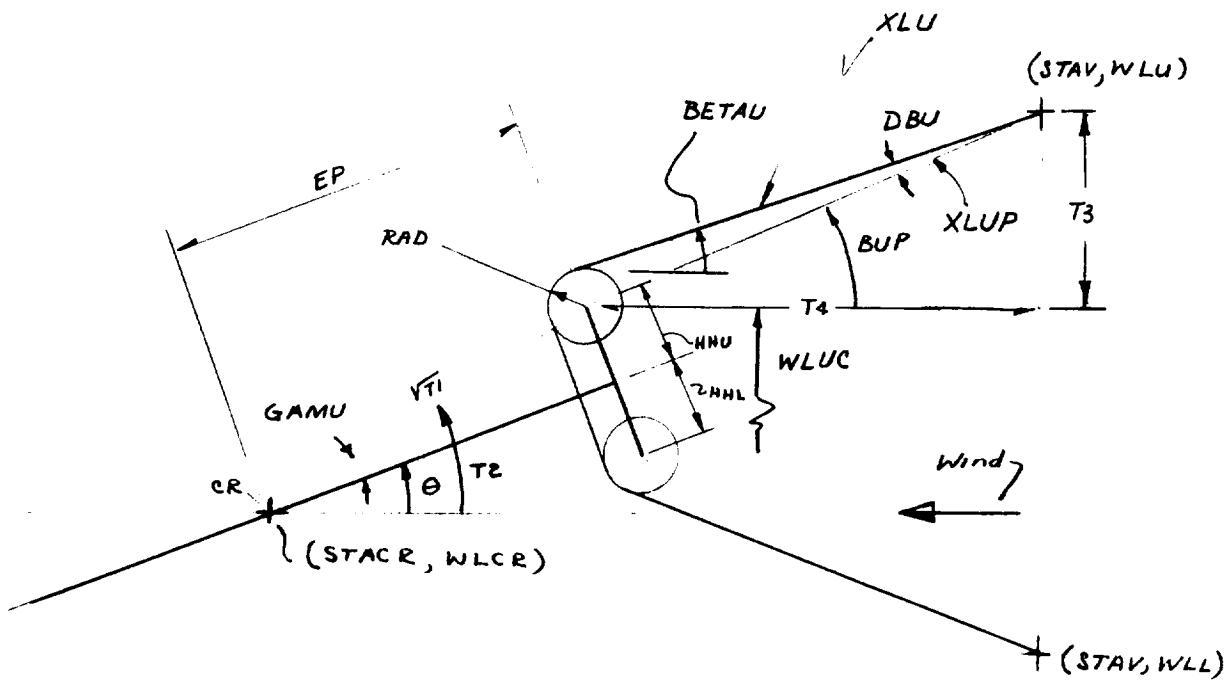


fig 4.3

$$GAMU = \tan^{-1} (HHU/EP)$$

$$T_1 = EP^2 + HHU^2$$

$$WLUC = LWCR + T_1 * \sin (GAMU + \theta)$$

$$T_3 = WLU - WLUC$$

$$T_4 = (STACR - STAV) - T_1 * \cos (GAMU + \theta)$$

$$BUP = \tan^{-1} (T_3/T_4)$$

$$XLUP = (T_3^2 + T_4^2)^{1/2}$$

$$\text{Length of Cable} = XLU = (XLUP^2 - RAD^2)^{1/2}$$

$$DBU = \tan^{-1} (RAD/XLU)$$

$$BETAU = (BUP - DBU)$$

FIG. 4.3 - GEOMETRIC DEFINITIONS AND EQUATIONS

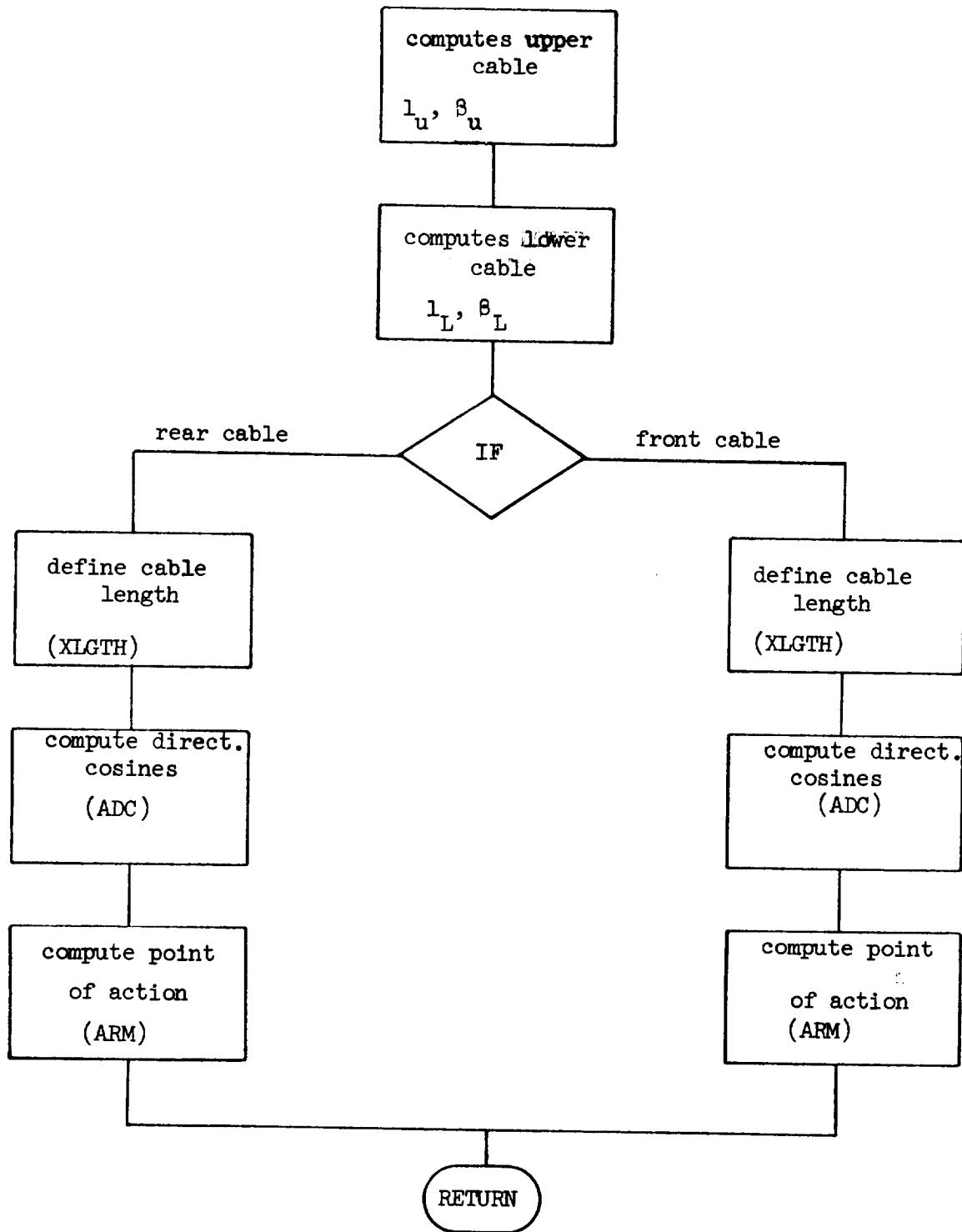
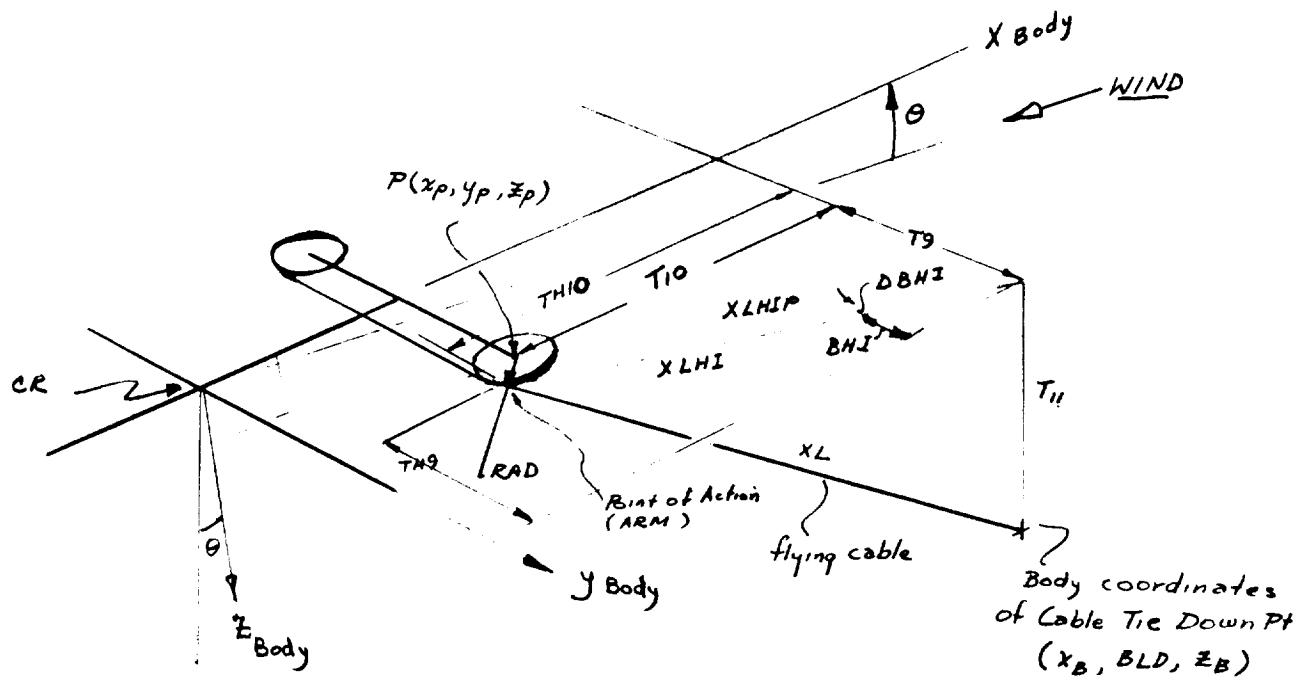


FIGURE 4.4 - FLOW CHART - SUBROUTINE FPLYV



x_p, y_p, z_p - body axis coordinates of pulley

x_B, BLD, z_B - body axis coordinate of cable attachment point

XL - length of cable - inches

XLHI - projection of cable onto x_{body} - y_{body} plane

RAD - pulley radius ~ inches

FIG. 4.5 - DEFINITION OF GEOMETRIC NOMENCLATURE

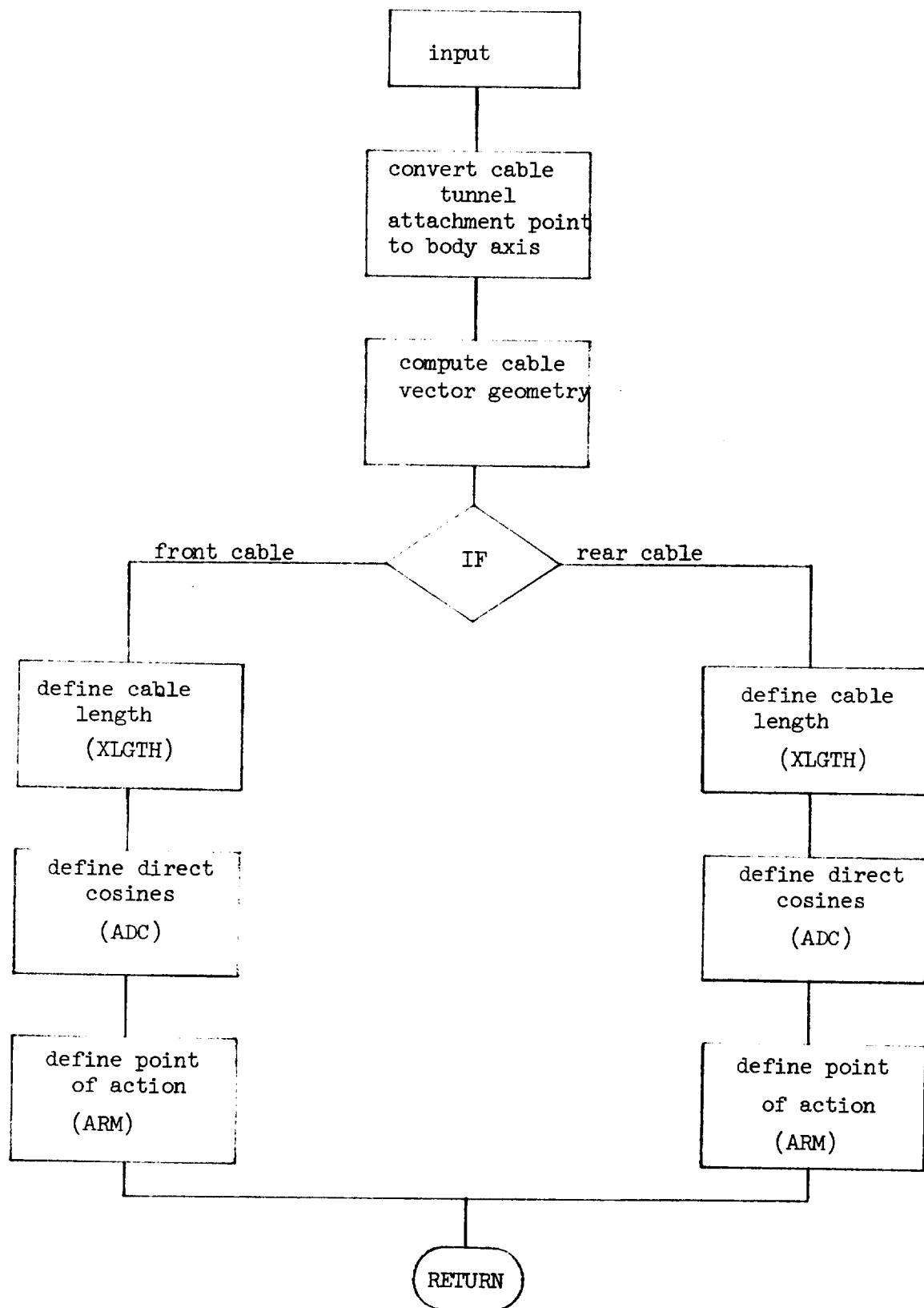


FIGURE 4.6 - FLOW CHART - SUBROUTINE RPLYH

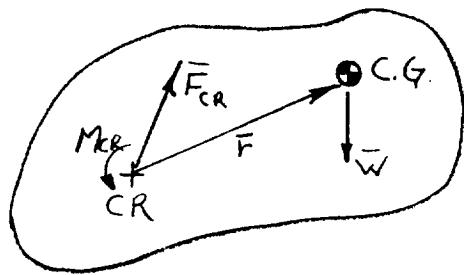
5.0 THEORETICAL DEVELOPMENT OF THE PERTURBED EQUATIONS OF MOTION FOR A CABLE SUSPENDED MODEL IN A WIND TUNNEL

The development is divided into four sub-sections. The first section presents a derivation of the linearized equations of motion. The following sections describe the derivation of the force and moment contributions due to the vehicle weight, aerodynamics and cable forces respectively.

5.1 DERIVATION OF LINEARIZED EQUATIONS OF MOTION

The linearized equation of motion is derived about the center of reference, "CR", rather than the center of gravity. The relative location is defined by the vector, \bar{r} , as shown in Figure 5.1.

\bar{F}_{CR} and \bar{M}_{CR} are the total force and moment less the weight contribution about point CR. Writing the equation of motion about the center of gravity:



$$\bar{F}_{CR} + \bar{m}\bar{g} = \bar{m}\bar{a}_{CG} \quad (5.1-1)$$

$$\bar{M}_{CR} - \bar{r} \times \bar{F}_{CR} = \frac{d}{dt} \bar{H} \quad (5.1-2)$$

Fig. 5.1

\bar{a} and \bar{H} are the translational acceleration and the angular momentum vector respectively.

The following relationships are noted for a rigid body

$$\text{Displacement: } \bar{x}_{CG} = \bar{x}_{CR} + \bar{r} \quad (5.1-3)$$

$$\text{Rate: } \bar{v}_{CG} = \bar{v}_{CR} + \bar{\omega} \times \bar{r} \quad (5.1-4)$$

$$\text{Acceleration: } \bar{a}_{CG} = \bar{a}_{CR} + \dot{\bar{\omega}} \times \bar{r} + \bar{\omega} \times (\bar{\omega} \times \bar{r}) \quad (5.1-5)$$

$$\bar{\omega}_{CG} = \bar{\omega}_{CR}$$

where $\bar{\omega}$ is the rotation vector of the model.

Substituting equation 5.1-5 into equation 5.1-1, we have:

$$\bar{F}_{CR} + m(\bar{g} - \dot{\bar{\omega}} \times \bar{r}) - m\bar{\omega} \times (\bar{\omega} \times \bar{r}) = m\bar{a}_{CR} \quad (5.1-6)$$

noting again that

$$\bar{H}_{CR} = \bar{H}_{CG} + m\bar{r} \times \frac{d\bar{r}}{dt} \quad (5.1-7)$$

$$\text{or } \bar{H}_{CR} = \bar{H}_{CG} + m\bar{r} \times \cancel{\dot{\bar{r}}} + \bar{\omega} \times \bar{r} \quad (5.1-8)$$

$$\text{and } \frac{d\bar{H}_{CR}}{dt} = \frac{d\bar{H}_{CG}}{dt} + m\bar{r} \times (\dot{\bar{\omega}} \times \bar{r} + \bar{\omega} \times (\bar{\omega} \times \bar{r})) \quad (5.1-9)$$

Equations 5.1-6 and 5.1-9 can be solved for \bar{F}_{CR} and \bar{H}_{CG} respectively, and the results substituted into equation 5.1-2. Cancelling like items on both sides of the equation reduces 5.1-2 to:

$$\bar{M}_{CR} - m\bar{r} \times (\bar{a}_{CR} - \bar{g}) = \frac{d\bar{H}_{CR}}{dt} \quad (5.1-10)$$

Equations 5.1-6 and 5.1-10 represent the equation of motion about the point, "CR".

Equation 5.1-6 can further be simplified by noting that the initial rates and accelerations are zero because the vehicle is statically trimmed in the tunnel. The $\bar{\omega}$ must necessarily be a perturbation vector and $\bar{\omega} \times (\bar{\omega} \times \bar{r})$ represents a higher order term which will be ignored in the linearizing of the equation.

Equations 5.1-6 and 5.1-10 can now be written in the form:

$$\bar{F}_{CR} + m(\bar{g} - \dot{\bar{\omega}} \times \bar{r}) = m(\dot{\bar{V}} + \bar{\omega} \times \bar{V})_{CR} \quad (5.1-11)$$

$$\bar{M}_{CR} + m[\bar{r} \times (\bar{g} - \bar{a}_{CR})] = (\dot{\bar{H}} + \bar{\omega} \times \bar{H})_{CR} \quad (5.1-12)$$

These results show that to study perturbation motion about a point other than the center of gravity, the form of the pseudo linearized equation of motion is similar to that about the C.G. except for the gravity terms which are modified by $\dot{\bar{\omega}}$ and \bar{a}_{CR} .

Expanding the right hand side of equations 5.1-11 and 5.1-12 and assuming symmetry about the x-z plane, we have

$$\begin{aligned}
 \sum F_x &= m (\dot{U} - RV + QW) \\
 \sum F_y &= m (\dot{V} - FW + RU) \\
 \sum F_z &= m (\dot{W} - QU + PV) \\
 \sum L &= \dot{P}I_x - (\dot{R} + PQ) I_{xz} - QR (I_y - I_z) \\
 \sum M &= \dot{Q}I_y - (R^2 - P^2) I_{xz} - RP (I_z - I_x) \\
 \sum N &= \dot{R}I_z - (P - QR) I_{xz} - PQ (I_x - I_y)
 \end{aligned} \tag{5.1-13}$$

The nomenclature in Eq 5.1-13 are used in the conventional manner. If each of the variables U,V,W, and P, Q, R are replaced by a steady state term plus an increment, e.g. $X = X_0 + \Delta X$: the expressions expanded and then noting that all the steady state terms are zero. 5.1-13 is simplified to

$$\begin{aligned}
 \sum F_x &= m\dot{U} \\
 \sum F_y &= m\dot{V} \\
 \sum F_z &= m\dot{W} \\
 \sum L &= \dot{P}I_x + \dot{r}I_{xz} \\
 \sum M &= \dot{q}I_y \\
 \sum N &= \dot{r}I_z - \dot{p}I_{xz}
 \end{aligned} \tag{5.1-14}$$

Returning to equation 5.1-11 and expanding the left hand side of the equation

$$\bar{F}_{CR} + \Delta\bar{F}_{CR} + m (\bar{g}_0 + \Delta\bar{g} - (\dot{\bar{\omega}}_0 + \dot{\bar{\omega}}) \times \bar{r}) = m\dot{\bar{v}} \tag{5.1-15}$$

we find that due to trim

$$\bar{F}_{CR} + \bar{mg}_0 = 0, \quad \dot{\bar{\omega}}_0 = 0 \tag{5.1-16}$$

the perturbed force equation is thus:

$$\bar{\Delta F}_{CR} + m (\bar{\Delta g} - \bar{\omega} \times \bar{r}) = m \dot{\bar{v}} \quad (5.1-17)$$

$$\text{or} \quad \bar{\Delta F}_{CR} + \bar{\Delta W} = m \dot{\bar{v}} \quad (5.1-18)$$

The perturbed moment equation 5.1-12 can be similarly derived:

$$\bar{\Delta M}_{CR} + \bar{\Delta M}_{CR} + m \left[\bar{r} \times (\bar{g}_o + \bar{\Delta g} + \dot{\bar{v}}) \right] = \dot{\bar{H}} \quad (5.1-19)$$

$$\text{For trim} \quad \bar{\Delta M}_{CR} + m \bar{r} \times \bar{g}_o = 0$$

$$\text{thus} \quad \bar{\Delta M}_{CR} + m [\bar{r} \times (\bar{\Delta g} - \dot{\bar{v}})] = \dot{\bar{H}} \quad (5.1-20)$$

$$\text{or} \quad \bar{\Delta M}_{CR} + \bar{\Delta M}_{wgt} = \dot{\bar{H}} \quad (5.1-21)$$

Equation 5.1-18 and 5.1-21 can finally be written as

$$\bar{\Delta F}_{aero_{CR}} + \bar{\Delta F}_{cable_{CR}} + \bar{\Delta W} = m \dot{\bar{v}} \quad (5.1-22)$$

$$\bar{\Delta M}_{aero_{CR}} + \bar{\Delta M}_{cable_{CR}} + \bar{\Delta M}_{wgt} = \dot{\bar{H}} \quad (5.1-23)$$

The development of the weight, aerodynamic and cable terms are described in the following sections, 5.2, 5.3 and 5.4 respectively.

5.2 EXPANSION OF WEIGHT TERMS

The weight contribution about the point, CR, is defined by equations 5.1-18 and 5.1-21.

$$\bar{\Delta W} = m (\bar{\Delta g} - \bar{\omega} \times \bar{r}) \quad (5.2-1)$$

$$\bar{\Delta M}_{wgt} = m [r \times (\bar{\Delta g} - \dot{\bar{v}})]$$

The $\bar{\Delta g}$ term is derived from the trim weight vector which has the following components along the trim axis:

$$\begin{aligned} g_{x0_t} &= g \sin \theta_o \\ g_{y0_t} &= g \cos \theta_o \cos \phi. \\ g_{z0_t} &= g \cos \theta_o \sin \phi. \end{aligned} \quad (5.2-2)$$

The Eulerian Transformation matrix 'E' for small perturbations is:

$$E = \begin{vmatrix} 1 & \psi & -\theta \\ \psi & 1 & \phi \\ \theta & -\phi & 1 \end{vmatrix} \quad (5.2-3)$$

The total contribution of \bar{g} along the instantaneous body axis is

$$\{ \bar{g}_B \} = E \{ g_t \} \quad (5.2-4)$$

Subtracting the steady state increment gives $\Delta \bar{g}_B$

$$\{ \Delta \bar{g}_B \} = E \{ g_t \} - \{ g_t \} = \left\{ \begin{array}{l} -g \cos \theta_o \dot{\theta} \\ g [\sin \theta_o \dot{\psi} + w \cos \theta_o \dot{\phi}] \\ g [-\sin \theta_o \dot{\theta} - \cos \theta_o \dot{\phi}] \end{array} \right\} \quad (5.2-5)$$

The effective weight vector can now be determined if we note that:

$$\frac{d}{dt} \vec{\omega} \times \vec{r} = \begin{vmatrix} \ddot{\phi} & \ddot{\theta} & \ddot{\psi} \\ XCG & 0 & ZCG \end{vmatrix} = \left\{ \begin{array}{l} ZCG \ddot{\theta} \\ XCG \ddot{\psi} - ZCG \ddot{\phi} \\ -XCG \ddot{\theta} \end{array} \right\} \quad (5.2-6)$$

$$\therefore \boxed{\Delta \bar{W} = m \left\{ \begin{array}{l} -g \cos \theta_o \dot{\theta} - ZCG \ddot{\theta} \\ g [\sin \theta_o \dot{\psi} + w \cos \theta_o \dot{\phi}] - [XCG \ddot{\psi} - ZCG \ddot{\phi}] \\ g [-\sin \theta_o \dot{\theta} - \cos \theta_o \dot{\phi}] + XCG \ddot{\theta} \end{array} \right\}} \quad (5.2-7)$$

The moment vector induced by the weight is determined

$$\Delta \bar{M}_{wgt} = m \begin{vmatrix} XCG & 0 & ZCG \\ \Delta g_{bx} \cdot x & \Delta g_{by} \cdot y & \Delta g_{bz} \cdot z \end{vmatrix} \quad (5.2-8)$$

$$\Delta \bar{M}_{WGT} = m \begin{Bmatrix} -ZCG (\Delta g_{by} - \ddot{y}) \\ ZCG (\Delta g_{bx} - \ddot{x}) - XCG (\Delta g_{bz} - \ddot{z}) \\ XCG (\Delta g_{by} - \ddot{y}) \end{Bmatrix} \quad (5.2-9)$$

where Δg_{bx} , Δg_{by} and Δg_{bz} are defined by equation 5.2-5

5.3 DERIVATION OF AERODYNAMIC CONTRIBUTION TO THE FORCES AND MOMENTS

The aerodynamic forces and moments of equation 5.1-22 and 5.1-23 can be expanded as equation 5.3-1.

$$\begin{aligned}
 \Delta F_{x_A} &= \frac{\partial F_{x_A}}{\partial \left(\frac{u}{V_o}\right)} \left(\frac{u}{V_o}\right) + \frac{\partial F_{x_A}}{\partial \left(\frac{\dot{u}}{2V_o^2}\right)} \left(\frac{\dot{u}}{2V_o^2}\right) + \frac{\partial F_{x_A}}{\partial \left(\frac{\dot{u}}{2V_o}\right)} \left(\frac{\dot{u}}{2V_o}\right) + \frac{\partial F_{x_A}}{\partial \delta_e} (\delta_e) \\
 \Delta F_{y_A} &= \frac{\partial F_{y_A}}{\partial \left(\frac{v}{V_o}\right)} \left(\frac{v}{V_o}\right) + \frac{\partial F_{y_A}}{\partial \left(\frac{\dot{v}}{2V_o^2}\right)} \left(\frac{\dot{v}}{2V_o^2}\right) + \frac{\partial F_{y_A}}{\partial \left(\frac{\dot{v}}{2V_o}\right)} \left(\frac{\dot{v}}{2V_o}\right) + \frac{\partial F_{y_A}}{\partial \left(\frac{rb}{2V_o}\right)} \left(\frac{rb}{2V_o}\right) \\
 &\quad + \frac{\partial F_y}{\partial \delta_R} (\delta_R) + \frac{\partial F_y}{\partial \delta_a} (\delta_a) \quad (5.3-1) \\
 \Delta F_{z_A} &= \frac{\partial F_{z_A}}{\partial \left(\frac{w}{V_o}\right)} \left(\frac{w}{V_o}\right) + \frac{\partial F_{z_A}}{\partial \left(\frac{\dot{w}}{2V_o^2}\right)} \left(\frac{\dot{w}}{2V_o^2}\right) + \frac{\partial F_{z_A}}{\partial \left(\frac{\dot{w}}{2V_o}\right)} \left(\frac{\dot{w}}{2V_o}\right) + \frac{\partial F_{z_A}}{\partial \delta_e} (\delta_e) \\
 \Delta L_A &= \frac{\partial L}{\partial \left(\frac{v}{V_o}\right)} \left(\frac{v}{V_o}\right) + \frac{\partial L}{\partial \left(\frac{\dot{v}}{2V_o^2}\right)} \left(\frac{\dot{v}}{2V_o^2}\right) + \frac{\partial L}{\partial \left(\frac{pb}{2V_o}\right)} \left(\frac{pb}{2V_o}\right) + \frac{\partial L}{\partial \left(\frac{rb}{2V_o}\right)} \left(\frac{rb}{2V_o}\right) \\
 &\quad + \frac{\partial L}{\partial \delta_r} (\delta_r) + \frac{\partial L}{\partial \delta_a} (\delta_a)
 \end{aligned}$$

$$\Delta M_A = \frac{\partial M}{\partial \left(\frac{u}{V_o}\right)} \left(\frac{u}{V_o}\right) + \frac{\partial M}{\partial \left(\frac{w}{V_o}\right)} \left(\frac{w}{V_o}\right) + \frac{\partial M}{\partial \left(\frac{\dot{c}}{2V_o}\right)} \left(\frac{\dot{c}}{2V_o}\right) + \frac{\partial M}{\partial \left(\frac{\dot{\theta}c}{2V_o}\right)} \left(\frac{\dot{\theta}c}{2V_o}\right) \\ + \frac{\partial M}{\partial \delta_e} (\delta_e)$$

$$\Delta N_A = \frac{\partial N}{\partial \left(\frac{v}{V_o}\right)} \left(\frac{v}{V_o}\right) + \frac{\partial N}{\partial \left(\frac{\dot{v}}{2V_o}\right)} \left(\frac{\dot{v}}{2V_o}\right) + \frac{\partial N}{\partial \left(\frac{pb}{2V_o}\right)} \left(\frac{pb}{2V_o}\right) + \frac{\partial N}{\partial \left(\frac{rb}{2V_o}\right)} \left(\frac{rb}{2V_o}\right) \\ + \frac{\partial N}{\partial \delta_r} (\delta_r) + \frac{\partial N}{\partial \delta_a} (\delta_a)$$

In the wind tunnel, the following relationship is true:

$$\frac{w}{V_o} = \theta + \frac{\dot{z}}{V_o}, \quad \frac{\dot{w}}{V_o} = \dot{\theta} + \frac{\ddot{z}}{V_o} \\ \frac{v}{V_o} = -\psi + \frac{\dot{y}}{V_o}, \quad \frac{\dot{v}}{V_o} = -\dot{\psi} + \frac{\ddot{y}}{V_o} \quad (5.3-2)$$

Substituting equations 5.3-2 and 5.1-4 into equation 5.3-2 and rewriting equation 5.3-2 in terms of the body axis coefficient we have:

$$\Delta F_{X_A} = \left[C_{x_w} \frac{qS}{V_o} \dot{x} + C_{x_\alpha} \frac{qS}{V_o} \dot{z} + C_{x_\alpha} \frac{qS\bar{c}}{2V_o^2} \ddot{z} + C_{x_\alpha} qS\theta \right. \\ \left. + \left(C_{x_\alpha} + C_{x_\theta} \right) \frac{qS\bar{c}}{2V_o} \dot{\theta} + C_{x_\delta_e} qS \delta_e \right] \quad (5.3-3.1)$$

$$\Delta F_{Y_A} = \left[C_{y_\beta} \frac{qS}{V_o} \dot{y} + C_{y_\beta} \frac{qS}{V_o} \ddot{y} + C_{y_p} \frac{qSb}{2V_o} \dot{\phi} + \left(-C_{y_\beta} + C_{y_r} \right) \frac{qSb}{2V_o} \dot{\psi} \right. \\ \left. - C_{y_\beta} qS\psi + C_{y_\delta_r} qS\delta_r + C_{y_\delta_a} qS\delta_a \right] \quad (5.3-3.2)$$

$$\Delta F_{Z_A} = \left[C_{z_u} \frac{qS}{V_o} \dot{x} + C_{z_\alpha} \frac{qS}{V_o} \dot{z} + C_{z_\alpha} \frac{qS\bar{c}}{2V_o^2} \ddot{z} + C_{z_\alpha} qS\theta + \left(C_{z_\alpha} + C_{z_\dot{\theta}} \right) \frac{qS\bar{c}}{2V_o} \dot{\theta} \right. \\ \left. + C_{z_\delta_e} qS \delta_e \right] \quad (5.3-3.3)$$

$$\Delta L_A = \left[C_{\ell_B} \frac{qSb}{V_o} \dot{y} + C_{\ell_B} \frac{qSb}{V_o} \ddot{y} + C_{\ell_p} \frac{qSb}{2V_o}^2 \dot{\phi} + \left(C_{\ell_r} - C_{\ell_B} \right) \frac{qSb}{2V_o}^2 \dot{\psi} \right. \\ \left. - C_{\ell_B} qSb \Psi + C_{\ell_{\delta_r}} qSb \delta_r + C_{\ell_{\delta_a}} qSb \delta_a \right] \quad (5.3-3.4)$$

$$\Delta M_A = \left[C_{m_u} \frac{qS_c}{V_o} \dot{x} + C_{m_\alpha} \frac{qS_c}{V_o} \dot{z} + C_{m_\alpha} \frac{qS_c}{2V_o}^2 \dot{z} + C_{m_\alpha} qS_c \theta \right. \\ \left. + \left(C_{m_\alpha} + C_{m_\theta} \right) \frac{qS_c}{2V_o}^2 \theta + C_{m_{\delta_e}} qS_c \delta_e \right] \quad (5.3-3.5)$$

$$\Delta N_A = \left[C_{n_B} \frac{qSb}{V_o} \dot{y} + C_{n_B} \frac{qSb}{V_o} \ddot{y} + C_{n_p} \frac{qSb}{2V_o}^2 \dot{\phi} + \left(C_{n_r} - C_{n_B} \right) \frac{qSb}{2V_o}^2 \dot{\psi} \right. \\ \left. - C_{n_B} qSb \Psi + C_{n_{\delta_r}} qSb \delta_r + C_{n_{\delta_a}} qSb \delta_a \right] \quad (5.3-3.6)$$

5.4 DERIVATION OF THE CABLE FORCES AND MOMENTS

The generalized force and moment equations for a single cable are defined. The forces and moments of the entire cable system are then obtained by the proper summation of each individual cable contribution.

For a single cable, a component of force along any trim axis can be written in terms of the tension in the cable and its direction cosine with respect to the axis. i.e.

$$F_i = T \cos \alpha_i \quad i = x, y \text{ or } z \quad (5.4-1)$$

The instantaneous force component, due to changes in the cable tension and direction cosine, along the trim axis can be defined as:

$$(F_o + \Delta F)_i = (T + \Delta T) \cos (\alpha + \Delta \alpha)_i \quad (5.4-2)$$

where F_o is the steady state force component and ΔF the change in this component. Expanding this expression and linearizing, we have:

$$F_{I_i} = (F_o + \Delta F)_i = T \cos \alpha_i + \Delta T \cos \alpha_i - T \Delta \alpha_i \sin \alpha_i \quad (5.4-3.1)$$

or $F_o_i = T \cos \alpha_i \quad (5.4-3.2)$

$$\Delta F_i = \Delta T \cos \alpha_i - T \Delta \alpha_i \sin \alpha_i \quad (5.4-3.3)$$

The force, in equation 5.4-2, is the instantaneous force along the trim body axis. The instantaneous body axis may be displaced through perturbation angles Ψ , θ and ϕ . To obtain the force along the instantaneous body axis, vector F_I , is transformed via the Eulerian transformation matrix defined in equation 5.2-2.

$$\left\{ F_I \right\}_B = \left\{ F_o + \Delta F \right\}_B = E \left\{ F_o + \Delta F \right\}_T \quad (5.4-4)$$

Expanded, equation 5.4-4 takes the following form:

$$\begin{aligned} \left\{ F_I \right\}_B &= \begin{vmatrix} 1 & \Psi & -\theta \\ -\Psi & 1 & \phi \\ \theta & -\phi & 1 \end{vmatrix} \left\{ F_o + \Delta F \right\}_T \\ &= \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix} \left\{ F_o \right\}_T + \begin{vmatrix} 0 & \Psi & -\theta \\ -\Psi & 0 & \phi \\ \theta & -\phi & 0 \end{vmatrix} \left\{ F_o \right\}_T \\ &\quad + \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix} \left\{ \Delta F \right\}_T + HOT \end{aligned} \quad (5.4-5)$$

The first term is the steady state term, the next term is due to rotation of the body axis and the third is due to the perturbation of the steady state force. Subtracting the steady state force, the incremental change in the cable force projected on the instantaneous body axis is obtained.

$$\{\Delta F_I\}_B = \left\{ \begin{bmatrix} \Delta F_{T_1} + \Psi F_{To_2} - \theta F_{To_3} \\ \Delta F_{T_2} - \Psi F_{To_1} + \phi F_{To_3} \\ \Delta F_{T_3} + \theta F_{To_1} - \phi F_{To_2} \end{bmatrix} \right\} \quad (5.4-6)$$

To determine the incremental change in moment about the instantaneous body axis, the vector notation of the generalized moment vector, \bar{K} , is written as:

$$\bar{K} = (\bar{x}_p \times \bar{F}_I)_B \quad (5.4-7)$$

\bar{x}_p is the vector from the center of rotation to the point of action of the cable force, \bar{F}_I . This vector has been defined in the trim analysis. \bar{F}_I is defined by the matrix in equation 5.4-5.

Expanding the equation and subtracting the steady state moment term out, the following is obtained:

$$\{\Delta K\} = \begin{bmatrix} \Delta L \\ \Delta M \\ \Delta N \end{bmatrix}_B = \left\{ \begin{bmatrix} y_p \Delta F_{T_3} - z_p \Delta F_{T_2} + z_p F_{To_1} \Psi - (y_p F_{To_2} + z_p F_{To_3}) \phi \\ z_p \Delta F_{T_1} - x_p \Delta F_{T_3} - (z_p F_{To_3} + x_p F_{To_1}) \theta \\ x_p \Delta F_{T_2} - y_p \Delta F_{T_1} - (x_p F_{To_1} + y_p F_{To_2}) \Psi + x_p F_{To_3} \phi \end{bmatrix} \right\} \quad (5.4-8)$$

Equations 5.4-6 and 5.4-8 are the generalized cable forces and moments for a single cable. The force terms with a subscript zero are defined by equation 5.4-3.2. The ΔF_i increments are obtained from equation 5.4-3.3 once ΔT and $\Delta \alpha_i$ are defined. The change in tension force, ΔT , is proportional to Δl via the spring constant. The $\Delta \alpha_i$ is the change in the direction cosine with respect to the trim axis.

To determine ΔT and $\Delta \alpha_i$ the vector representation of the cable at any instant of time must be defined with respect to the trim axis.

Let \bar{X}_{WT} represent the vector to the cable tie-down point the tunnel wall from the center of reference in the trim axis systems and \bar{X}_{P_B} the vector to the point of action in the body axis. Let \bar{X}_{P_T} be the transformation of \bar{X}_{P_B} onto the trim axis system. i.e.

$$\bar{X}_{P_T} = \left\{ X_p \right\}_T = E^{-1} \left\{ X_p \right\}_B \quad (5.4-9)$$

The cable vector is thus defined by equation 5.4-10

$$\bar{A} = \bar{X}_{WT} - \bar{X}_{P_T} = \left\{ l \cos \alpha_i + \delta_i \right\}_{i=1,2,3} \quad (5.4-10)$$

where δ_i is defined by the following:

$$\begin{aligned} \delta_1 &= -(-y_p^\Psi + z_p^\Theta + x) \\ \delta_2 &= -(x_p^\Psi - z_p^\Phi + y) \\ \delta_3 &= (-x_p^\Theta + y_p^\Phi + z) \end{aligned} \quad (5.4-11)$$

$x, y, z, \Psi, \Theta, \Phi$ are perturbation variables.

The magnitude of \bar{A} is the instantaneous length of the cable. Expanding and linearizing the equation gives the following:

$$l_o + \Delta l = | \bar{A} | = l_o + \sum_{i=1}^3 \cos \alpha_i \delta_i \quad (5.4-12)$$

or

$$\Delta l = \sum \cos \alpha_i \delta_i \quad (5.4-13)$$

The incremental change in direction cosine can be determined by defining the unit vector along \bar{A} and then taking the dot product along the x, y, z axis.

$$\cos (\alpha + \Delta \alpha)_i = \left(\frac{\bar{A}}{l + \Delta l} \right) \cdot \bar{u}_i \quad (5.4-14)$$

where \bar{u}_i is the unit vector along the i^{th} trim axis

Expanding and linearizing:

$$\begin{aligned} l \cos \alpha_i + \Delta l \cos \alpha_i - \Delta \alpha_i l \sin \alpha_i &= \bar{A} \cdot \bar{u}_i \\ &= (x_{wt} - x_{pt}) \cdot \bar{u}_i \end{aligned} \quad (5.4-15)$$

$$\text{or } \Delta \alpha_i = \frac{1}{l \sin \alpha_i} \left[l \cos \alpha_i + \Delta l \cos \alpha_i - (x_{wt} - x_{pt}) \cdot \bar{u}_i \right] \quad (5.4-16)$$

Since from equation 5.4-10 :

$$(x_{wt} - x_{pt}) \cdot \bar{u}_i = (l \cos \alpha_i + \delta_i) \quad (5.4-17)$$

Equation 5.4-16 simplifies to:

$$\Delta \alpha_i = \frac{1}{l \sin \alpha_i} [\Delta l \cos \alpha_i - \delta_i]$$

(5.4-18)

Equations 5.4-13 and 5.4-18 are the necessary equations to define ΔF in equations 5.4-6 and 5.4-8. In Sections 6.0 and 7.0, these equations are simplified for the longitudinal and lateral directional analysis to obtain the influence coefficient matrix.

6.0 Longitudinal Stability Analysis

6.1 Subroutine LONG

This subroutine computes the perturbed forces and moments for the longitudinal perturbation equations of motion and extracts the characteristic roots for a stability analysis.

The general form of the linearized equation of motion (5.1-14) is reduced to equation 6.1-1 for the longitudinal analysis.

$$\begin{aligned}\Sigma \Delta F_x &= m\dot{u} = mx \\ \Sigma \Delta F_z &= m\dot{w} = mz \\ \Sigma \Delta M_y &= I_y \ddot{\theta} = I_y \theta\end{aligned}\quad (6.1-1)$$

x , z and θ are the longitudinal perturbation variables. $\Sigma \Delta F_x$, $\Sigma \Delta F_z$ and $\Sigma \Delta M$ are further expanded in equation 6.1-2.

$$\begin{aligned}\Sigma \Delta F_x &= \Delta F_{x_{aero}} + \Delta F_{x_{wt}} + \Delta F_{x_{cable}} + \Delta F_{x_{snubber}} \\ \Sigma \Delta F_z &= \Delta F_{z_{aero}} + \Delta F_{z_{wt}} + \Delta F_{z_{cable}} + \Delta F_{z_{snubber}} \\ \Sigma \Delta M_y &= \Delta M_{aero} + \Delta M_{wt} + \Delta M_{cable} + \Delta M_{snubber}\end{aligned}\quad (6.1-2)$$

The aerodynamic forces and moments, $\Delta F_{x_{aero}}$, $\Delta F_{z_{aero}}$ and ΔM_{aero} , are defined by equations 5.3-3.1, 5.3-3.3 and 5.3-3.5 respectively. The weight contributions are defined by equations 5.2-7 and 5.2-9 and simplify to equation 6.1-3 with y , Ψ , $\phi = 0$.

$$\begin{aligned}\Delta F_{x_{wt}} &= W \cos \theta_o \theta - z_{CG} M \ddot{\theta} \\ \Delta F_{z_{wt}} &= W \sin \theta_o \theta = x_{CG} M \ddot{\theta} \\ \Delta M_{wt} &= z_{CG} (W \cos \theta_o \theta + mx) + x_{CG} (W \sin \theta_o \theta + mz)\end{aligned}\quad (6.1-3)$$

The cable forces and moment are obtained from generalized equations 5.4-6 and 5.4-8 respectively.

$$\begin{aligned}\Delta F_1 &= \Delta F_x = \Delta F_{T_1} - \theta F_{To_3} \\ \Delta F_3 &= \Delta F_z = \Delta F_{T_3} + \theta F_{To_1} \\ \Delta M_y &= z_p \Delta F_{T_1} - x_p \Delta F_{T_3} - (z_p F_{To_3} + x_p F_{To_1}) \theta\end{aligned}\quad (6.1-4)$$

where according to equations 5.4-3.2 and 5.4-3.3

$$\begin{aligned}F_{To_i} &= T_i \cos \alpha_i \quad i = 1, 3 \\ \text{and} \\ \Delta F_{T_i} &= \Delta T_i \cos \alpha_i - T \Delta \alpha_i \sin \alpha_i\end{aligned}\quad (6.1-5)$$

The steady state direction cosine angle, α_i and cable tension, T_i are obtained from the trim analysis. The ΔT_i and $\Delta \alpha_i$ are proportional to the longitudinal perturbation variables. The ΔT_i for the rear cable is defined by equation 6.1-6 .

$$\Delta T_R = AKR (\Delta \ell_3 + \Delta \ell_4) \quad (6.1-6)$$

The ΔT_F for the front cable is a variable in the analysis.

The constant front cable length requirement is a constraint equation which in conjunction with the equations of motion defines a unique solution of the variables x , z , θ and ΔT_F .

The constraint equation is:

$$\Delta \ell_1 + \Delta \ell_2 = 0 \quad (6.1-7)$$

Since:

$$\Delta \ell_1 = \frac{\partial \Delta \ell_1}{\partial x} x + \frac{\partial \Delta \ell_1}{\partial z} z + \frac{\partial \Delta \ell_1}{\partial \theta} \theta \quad (6.1-8)$$

$$\Delta \ell_2 = \frac{\partial \Delta \ell_2}{\partial x} x + \frac{\partial \Delta \ell_2}{\partial z} z + \frac{\partial \Delta \ell_2}{\partial \theta} \theta \quad (6.1-9)$$

The following relation of $x = f(z, \theta)$ is determined.

$$x = \frac{\left[\left(\frac{\partial \Delta l_1}{\partial z} + \frac{\partial \Delta l_2}{\partial z} \right) z + \left(\frac{\partial \Delta l_1}{\partial \theta} + \frac{\partial \Delta l_2}{\partial \theta} \right) \theta \right]}{\left(\frac{\partial \Delta l_1}{\partial x} + \frac{\partial \Delta l_2}{\partial x} \right)} \quad (6.1-10)$$

The coefficients for Δl_i are defined by subroutine DLGTH described in Section 6.3. Similarly the coefficient of $\Delta \alpha_i$ are defined in subroutine DCOSLG.

The cable forces and moment equations are reduced to functions of the basic variables x , z , θ and ΔT_F via the subroutine MASH for each individual cable. The results are then summed in the FXS array which in its final form, becomes the cable influence coefficient matrix. The initial form of the cable matrix for the front and rear flying cable are presented in Figures 6.1 and 6.2 respectively.

The stability characteristic matrix and the expanded form of the equations of motion are presented in Figure 6.3. A functional flow diagram of subroutine LONG is included as Figure 6.4.

6.2 Subroutine DLGTH

This subroutine computes the change in length of a cable for either the longitudinal or the lateral/directional perturbation stability analysis. An index, IDX, determines the mode that is being analyzed, and the correct form of Δl is computed.

The variation of the cable length with respect to the longitudinal variables is defined by the partial derivatives in equation 6.2-1.

$$\Delta l = \frac{\partial \Delta l}{\partial x} x + \frac{\partial \Delta l}{\partial z} z + \frac{\partial \Delta l}{\partial \theta} \theta \quad (6.2-1)$$

These "partials" are determined from the generalized form for Δl in equations 5.4-13 and 5.4-11. Equating the lateral/directional perturbation variables, y , ϕ and ψ to zero, the equation for Δl is reduced to the following simplified form.

$$\Delta l = -\cos \alpha_1 x - \cos \alpha_3 z + (x_p \cos \alpha_3 - z_p \cos \alpha_1) \theta \quad (6.2-2)$$

The subscripts 1 and 3 refer to the x and z body axis respectively. x_p and z_p corresponds to the coordinates of the cable force point of action. In the program, an added subscript, IC, is used

to define the particular cable being analyzed.

In the lateral directional mode, the coefficient of the y , Ψ , and ϕ variables in the lateral directional form of $\Delta\ell$ is computed.

$$\Delta\ell = \frac{\partial\Delta\ell}{\partial y} y + \frac{\partial\Delta\ell}{\partial\Psi} \Psi + \frac{\partial\Delta\ell}{\partial\phi} \phi \quad (6.2-3)$$

The coefficients are again obtained from equations 5.4-13 and 5.4-11, but now x , z , and θ is assumed zero. The expression for $\Delta\ell$ is reduced to equation 6.2-4.

$$\begin{aligned} \Delta\ell = & -\cos\alpha_2 y + [y_p \cos\alpha_1 - x_p \cos\alpha_2] \Psi + [z_p \cos\alpha_2 \\ & - y_p \cos\alpha_3] \phi \end{aligned} \quad (6.2-4)$$

The subscript 2 refers to the y body axis.

The expressions in equations 6.2-2 and 6.2-4 can be shown to be algebraically equivalent to their corresponding expressions in Reference 1. A functional flow diagram is included in Figure 6.3.

6.3 Subroutine DCOSLG

This subroutine computes the components of the $\Delta\alpha_1$ and $\Delta\alpha_3$ vectors required by subroutine LONG. Due to the symmetry of the longitudinal analysis, $\Delta\alpha_2$ is not required. The expressions for both $\Delta\alpha_1$ and $\Delta\alpha_3$ are obtained from equation 5.4-18. Expanding this expression and letting y , Ψ , and ϕ equal zero, the expressions for $\Delta\alpha_1$ and $\Delta\alpha_3$ are developed.

$$\begin{aligned} \Delta\alpha_1 = & \left(\frac{\sin\alpha_1}{\ell} \right) x + \left(\frac{\cos\alpha_3 \cot\alpha_1}{\ell} \right) z \\ & + \left(\frac{z_p \sin\alpha_1 + x_p \cos\alpha_3}{\ell} \right) \theta \\ \Delta\alpha_3 = & - \left(\frac{\cos\alpha_1 \cot\alpha_3}{\ell} \right) x + \left(\frac{\sin\alpha_3}{\ell} \right) z \\ & - \left(\frac{z_p \cos\alpha_1 \cot\alpha_3 + x_p \sin\alpha_3}{\ell} \right) \theta \end{aligned}$$

The subscripts 1 or 3 again refer to the x and z axis respectively. The x_p and z_p are the x and z components of the vector from the center of reference to the point of action of the cable force.

LONGITUDINAL FRONT CABLE MATRIX

β	θ	ΔT_F	χ	$\Delta \alpha_1$	$\Delta \alpha_3$
①	$-T \cos \alpha_3$	$\cos \alpha_1$		$-T \sin \alpha_1$	
②	$T \cos \alpha_1$	$\cos \alpha_3$		$-T \sin \alpha_3$	
③	$-3_p T \cos \alpha_3 - x_p T \cos \alpha_1 - x_p \cos \alpha_3$			$-3_p T \sin \alpha_1$	$x_p T \sin \alpha_3$
④	$\frac{\partial \chi}{\partial \beta}$		-1		
⑤	$\Delta \alpha_1 \beta$		$\Delta \alpha_{1x}$	-1	
⑥	$\Delta \alpha_3 \beta$		$\Delta \alpha_{3x}$		-1

Equation:

- ① $\Delta F_{x_c} = \Delta F_T - \Theta F_{T03} = (\cos \alpha, \Delta T_F - T_{F0} \sin \alpha, \Delta \alpha_1) - T_{F0} \cos \alpha_3 \Theta \quad (\text{eq } 6.1-4)$
- ② $\Delta F_{2c} = \Delta F_{T3} + \Theta F_{T01} = (\cos \alpha_3 \Delta T_F - T_{F0} \sin \alpha_3 \Delta \alpha_3) + T_{F0} \cos \alpha_1 \Theta \quad (\text{eq } 6.1-4)$
- ③ $\Delta M_c = 3_p \Delta F_{T1} - x_p \Delta F_{T3} - (3_p F_{T03} + x_p F_{T01}) \Theta \quad (\text{eq } 6.1-4)$
- ④ $\chi = \frac{\partial \chi}{\partial \beta} \beta + \frac{\partial \chi}{\partial \Theta} \Theta \quad (\text{eq } 6.1-10)$
- ⑤ $\Delta \alpha_1 = \Delta \alpha_{1x} \beta + \Delta \alpha_{10} \Theta + \Delta \alpha_{1x} \chi \quad (\text{eq } 6.3-1)$
- ⑥ $\Delta \alpha_3 = \Delta \alpha_{3x} \beta + \Delta \alpha_{30} \Theta + \Delta \alpha_{3x} \chi \quad (\text{eq } 6.3-2)$

FIG. 6.1 - MATRIX

LONGITUDINAL REAR CLE MATRIX

δ	Θ	χ	ΔT_E	$\Delta \alpha_1$	$\Delta \alpha_3$	$\Delta \ell_3 + \Delta \ell_4$
①	$-T_E \cos \alpha_3$		$\cos \alpha_1$	$-T_E \sin \alpha_1$		
②	$T_E \cos \alpha_1$		$\cos \alpha_3$		$-T_E \sin \alpha_3$	
③	$-\beta_P T_E \cos \alpha_3 - \gamma_P T_E \cos \alpha_1$	$\beta_P \cos \alpha_1 - \gamma_P \cos \alpha_3$	$-\beta_P T_E \sin \alpha_1$	$\gamma_P T_E \sin \alpha_3$		
④			$-I$		AKE	
⑤	$\Delta \alpha_{1,3}$	$\Delta \alpha_{1,x}$		$-I$		
⑥	$\Delta \alpha_{3,3}$	$\Delta \alpha_{1,x}$			$-I$	
⑦	$\Delta \ell_{3,y} + \Delta \ell_{4,y}$	$\Delta \ell_{3,x} + \Delta \ell_{4,x}$			$-I$	

Equations

- ① $\Delta F_{1c} = \Delta F_{T_1} - \Theta F_{T_3} : (\cos \alpha_1 \Delta T_E - T_E \sin \alpha_1 \Delta \alpha_1) - T_E \cos \alpha_3 \Theta \quad (\text{eq. 6.1-4})$
- ② $\Delta F_{2c} = \Delta F_{T_3} + \Theta F_{T_1} : (\cos \alpha_3 \Delta T_E - T_E \sin \alpha_3 \Delta \alpha_3) + T_E \cos \alpha_1 \Theta \quad (\text{eq. 6.1-4})$
- ③ $\Delta M_c = \beta_P \Delta F_{T_1} - \gamma_P \Delta F_{T_3} - (\beta_P F_{T_3} + \gamma_P F_{T_1}) \Theta \quad (\text{eq. 6.1-4})$
- ④ $\Delta T_E = AKE (\Delta \ell_3 + \Delta \ell_4)$ (eq. 6.1-6)
- ⑤ $\Delta \alpha_1 = \Delta \alpha_{1,3} + \Delta \alpha_{1,x} \Theta + \Delta \alpha_{1,x} \chi \quad (\text{eq. 6.3-1})$
- ⑥ $\Delta \alpha_3 = \Delta \alpha_{3,3} + \Delta \alpha_{3,x} \Theta + \Delta \alpha_{3,x} \chi \quad (\text{eq. 6.3-2})$
- ⑦ $\Delta \ell_3 + \Delta \ell_4 = (\Delta \ell_3 + \Delta \ell_4)_y \beta + (\Delta \ell_{3x} + \Delta \ell_{4x}) \Theta + (\Delta \ell_{3x} + \Delta \ell_{4x}) \chi \quad (\text{eq. 6.2-1})$

FIG. 6.2 - MATRIX

LONGITUDINAL CHARACTERISTIC MATRIX EQUATIONS

$\ddot{\theta}$	$\dot{\theta}$	ΔT_F	ω
$- \left[\left(\frac{\partial X_{L1}}{\partial \dot{x}} \right) A^2 + \left(\frac{\partial X_A}{\partial \dot{x}} + \frac{\partial X_{SN}}{\partial \dot{x}} \right) A + \frac{\partial X_c}{\partial \dot{x}} \right]$	$m Z_{CG} A^2 - \left(\frac{\partial X_h}{\partial \dot{z}} + \frac{\partial X_A}{\partial \dot{z}} + \frac{\partial X_{SN}}{\partial \dot{z}} \right) A + m G \cos \theta_0 - \left(\frac{\partial X_c}{\partial \dot{z}} + \frac{\partial X_{SN}}{\partial \dot{z}} \right)$	$- \frac{\partial X_c}{\partial \Delta T_F}$	$m A^2 - \left(\frac{\partial X_h}{\partial u} + \frac{\partial X_{SN}}{\partial u} \right) A - \frac{\partial X_c}{\partial x}$
$(m - \frac{\partial z}{\partial \dot{x}}) A^2 - \left(\frac{\partial Z_A}{\partial \dot{x}} + \frac{\partial Z_{SN}}{\partial \dot{x}} \right) A - \frac{\partial Z_c}{\partial \dot{x}}$	$-m X_{CG} A^2 - \left(\frac{\partial Z_h}{\partial \dot{z}} + \frac{\partial Z_A}{\partial \dot{z}} + \frac{\partial Z_{SN}}{\partial \dot{z}} \right) A + m G \sin \theta_0 - \left(\frac{\partial Z_c}{\partial \dot{z}} + \frac{\partial Z_{SN}}{\partial \dot{z}} \right) A - \frac{\partial Z_c}{\partial \Delta T_F}$	$- \frac{\partial Z_c}{\partial \Delta T_F}$	$- \left(\frac{\partial Z_A}{\partial u} + \frac{\partial Z_{SN}}{\partial u} \right) A - \frac{\partial Z_c}{\partial x}$
$- \left(\frac{\partial M_A}{\partial \dot{x}} \right) A^2 - \left(\frac{\partial M_{SN}}{\partial \dot{x}} + \frac{\partial M_h}{\partial \dot{x}} \right) A - \frac{\partial M_c}{\partial \dot{x}}$	$I_{xx} A^2 - \left(\frac{\partial M_h}{\partial \dot{z}} + \frac{\partial M_A}{\partial \dot{z}} + \frac{\partial M_{SN}}{\partial \dot{z}} \right) A - \left(\frac{\partial M_c}{\partial \dot{z}} + \frac{\partial M_{SN}}{\partial \dot{z}} \right) A - \frac{\partial M_c}{\partial \Delta T_F}$	$- \frac{\partial M_c}{\partial \Delta T_F}$	$m Z_{CG} A^2 - \left(\frac{\partial M_h}{\partial u} + \frac{\partial M_{SN}}{\partial u} \right) A - \frac{\partial M_c}{\partial x}$
$-\frac{\partial x}{\partial \dot{z}}$	$- \frac{\partial z}{\partial \dot{z}}$	1	

X - Force Equation:

$$m \ddot{x} = \frac{\partial X_h}{\partial u} \dot{x} + \frac{\partial Z_h}{\partial z} \dot{z} + \frac{\partial X_A}{\partial u} \dot{u} + \frac{\partial Z_A}{\partial z} \dot{z} + \frac{\partial X_{SN}}{\partial u} \dot{u} + \frac{\partial Z_{SN}}{\partial z} \dot{z} + \frac{\partial X_c}{\partial u} \dot{u} + \frac{\partial Z_c}{\partial z} \dot{z} + m \sin \theta_0 \cdot \theta - m Z_{CG} \dot{\theta} + m G \cos \theta_0 \cdot \theta - m G \sin \theta_0 \cdot \dot{\theta} + \frac{\partial Z_h}{\partial \dot{z}} \dot{z} + \frac{\partial Z_A}{\partial \dot{z}} \dot{z} + \frac{\partial Z_{SN}}{\partial \dot{z}} \dot{z} + \frac{\partial Z_c}{\partial \dot{z}} \dot{z},$$

Aero Weight Cable Spring Force Snubbin Damping Force

Z - Force Equation:

$$m \ddot{z} = \frac{\partial Z_h}{\partial u} \dot{x} + \frac{\partial Z_A}{\partial u} \dot{u} + \frac{\partial Z_{SN}}{\partial u} \dot{u} + \frac{\partial Z_c}{\partial u} \dot{u} + \frac{\partial X_h}{\partial z} \dot{x} + \frac{\partial X_A}{\partial z} \dot{u} + \frac{\partial X_{SN}}{\partial z} \dot{u} + \frac{\partial X_c}{\partial z} \dot{u} - m \sin \theta_0 \cdot \theta - m Z_{CG} \dot{\theta} + \frac{\partial Z_h}{\partial \dot{z}} \dot{z} + \frac{\partial Z_A}{\partial \dot{z}} \dot{z} + \frac{\partial Z_{SN}}{\partial \dot{z}} \dot{z} + \frac{\partial Z_c}{\partial \dot{z}} \dot{z},$$

Aero Weight Cable Spring Force Snubbin Damping Force

Pitching Mow. Equation:

$$I_{yy} \ddot{\theta} = \frac{\partial M_h}{\partial u} \dot{x} + \frac{\partial M_A}{\partial u} \dot{u} + \frac{\partial M_{SN}}{\partial u} \dot{u} + \frac{\partial M_c}{\partial u} \dot{u} + \frac{\partial M_h}{\partial z} \dot{z} + \frac{\partial M_A}{\partial z} \dot{z} + \frac{\partial M_{SN}}{\partial z} \dot{z} + \frac{\partial M_c}{\partial z} \dot{z} + m G \sin \theta_0 \cdot \theta - m G \cos \theta_0 \cdot \dot{\theta} + \frac{\partial M_h}{\partial \dot{z}} \dot{z} + \frac{\partial M_A}{\partial \dot{z}} \dot{z} + \frac{\partial M_{SN}}{\partial \dot{z}} \dot{z} + \frac{\partial M_c}{\partial \dot{z}} \dot{z},$$

Constraint Equation: $x = - \frac{\partial x}{\partial \dot{z}} \dot{z} - \frac{\partial z}{\partial \dot{z}} \dot{z}$

Auxiliary Equations: $\dot{x} = \dot{u} + \dot{z}, \quad \dot{u} = \dot{z}$

FIG. 6.3 - MATRIX

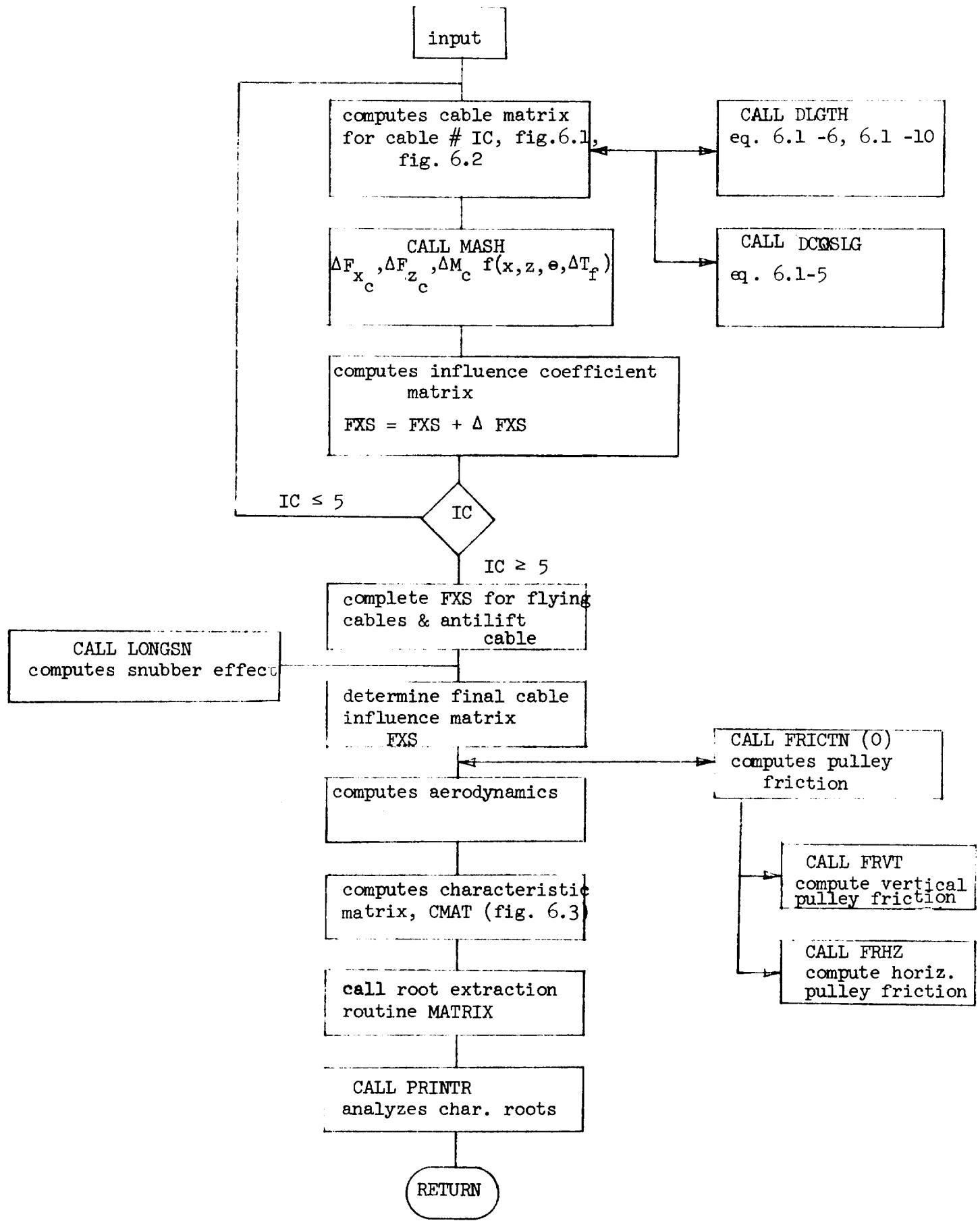
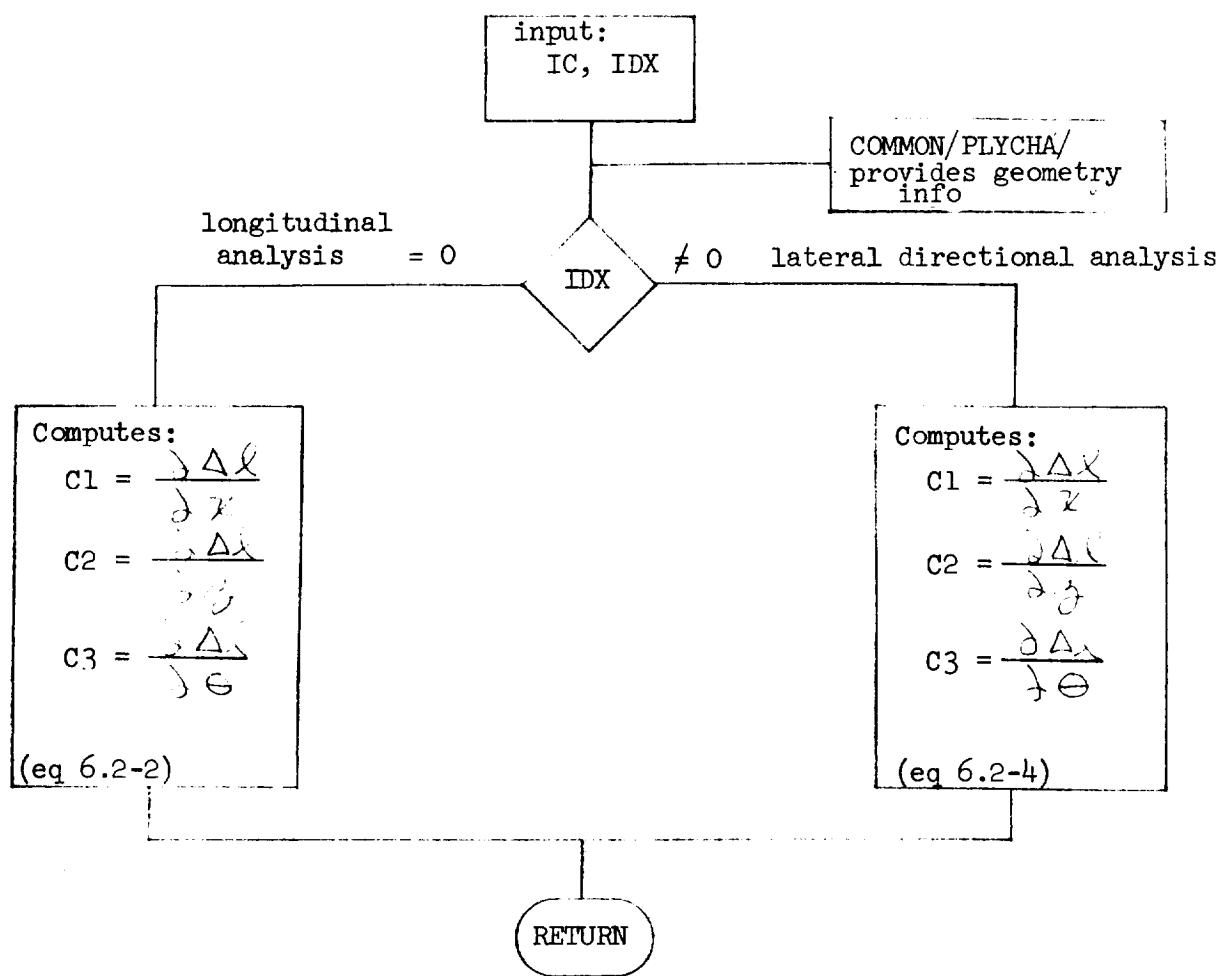


FIGURE 6.4 - FLOW CHART - SUBROUTINE LONG



IC = cable no., 1 - front upper or front starboard pulley
 2 - front lower or front port-side pulley
 3 - rear upper or rear starboard pulley
 4 - rear lower or rear port-side pulley
 5 - anti-lift cable

FIGURE 6.5 - FLOW CHART - SUBROUTINE DLGTH

7.0 Lateral Directional Stability Analysis

7.1 Subroutine LAT

This subroutine computes the forces and moments for the perturbed lateral/directional equations of motion and extracts the characteristic roots for the stability analysis.

The equations of motion, equation 5.1-14, are reduced to 7.1-1 for the lateral/directional analysis.

$$\begin{aligned}\Sigma \Delta F_y &= m \ddot{y} \\ \Sigma \Delta M_x &= \ddot{\phi} I_x + \ddot{\psi} I_{xz} \\ \Sigma \Delta M_z &= \ddot{\psi} I_z - \dot{\phi} I_{xz}\end{aligned}\quad (7.1-1)$$

where

$$\begin{aligned}\Sigma \Delta F_y &= \Delta F_{y_{\text{aero}}} + \Delta F_{y_{\text{cable}}} + \Delta W_y \\ \Sigma \Delta M_x &= \Delta L_{\text{aero}} + \Delta L_{\text{cable}} + \Delta L_{\text{WGT}} \\ \Sigma \Delta M_z &= \Delta N_{\text{aero}} + \Delta N_{\text{cable}} + \Delta N_{\text{WGT}}\end{aligned}\quad (7.1-2)$$

y , ψ and ϕ represent lateral/directional perturbation variables:

The aerodynamic forces and moments, $\Delta F_{y_{\text{aero}}}$, ΔL_{aero} and ΔN_{aero} are defined by equations 5.3-3.2, 5.3-3.4 and 5.3-3.6 respectively. The generalized weight contributions are defined by equations 5.2-7 and 5.2-9. The expressions are simplified with x , z and $\alpha = 0$.

$$\begin{aligned}\Delta W_y &= [WS \sin \theta_o \psi + W \cos \theta_o \phi] - m [XCG \ddot{\psi} - ZCG \ddot{\phi}] \\ \Delta L_{\text{WGT}} &= -ZCG [(W \sin \theta_o \psi + W \cos \theta_o \phi) - my] \\ \Delta N_{\text{WGT}} &= XCG [(W \sin \theta_o \psi + W \cos \theta_o \phi) - my]\end{aligned}\quad (7.1-3)$$

The cable forces and moments are determined by equations 5.4-6 and 5.4-8. These equations reduce to equation 7.1-4 for x , z and θ zero.

$$\Delta F_I = \Delta F_{T_2} - \Psi F_{To_1} + \phi F_{To_3} \quad (7.1-4)$$

$$\Delta L_I = \left(y_p \Delta F_{T_3} - z_p \Delta F_{T_2} \right) + z_p F_{To_1} \Psi - \left(y_p F_{To_2} + z_p F_{To_3} \right) \phi$$

$$\Delta N_I = \left(x_p \Delta F_{T_2} - y_p \Delta F_{T_1} \right) - \left(x_p F_{To_1} + y_p F_{To_2} \right) \Psi + \left(x_p F_{To_3} \right) \phi$$

The F_{To} and ΔF_T components are defined by equations 5.4-3.2 and 5.4-3.3:

$$F_{To_i} = T \cos \alpha_i - T \Delta \alpha_i \sin \alpha_i \quad (5.4-3.2)$$

$$\Delta F_{T_i} = \Delta T_i \cos \alpha_i - T \Delta \alpha_i \sin \alpha_i \quad (5.4-3.3)$$

The steady state terms, T and α_i , are determined by the trim analysis. The perturbation terms, ΔT_i and $\Delta \alpha_i$, are proportional to y , Ψ and ϕ . In the lateral directional analysis, the rear cable tension, ΔT_{R_i} , is assumed proportional to the change in rear cable length.

$$\Delta T_{R_i} = AKR (\Delta \ell_3 + \Delta \ell_4) \quad (7.1-5)$$

The perturbed front cable tension, ΔT_{F_i} , is assumed to be zero in

the analysis. The perturbed cable length, $\Delta \ell_i$, and cable direction cosine, $\Delta \alpha_i$, are computed in subroutines DLGTH and DCOSD respectively. These routines are described in Sections 6.2 and 7.2.

For each cable, the force and moment equations are reduced to functions of y , Ψ and ϕ via the subroutine MASH. The results are then summed for all cables in the FXS array. The final FXS array is the lateral/directional cable influence matrix. The form of the initial matrix prior to using MASH is shown in Figure 7.1.

Subsequent to computing the cable matrix, the lateral/directional stability characteristic matrix is generated. Figure 7.2 shows the elements of the matrix and the expanded equations of motion which it represents. A routine which reduces the matrix to a characteristic polynomial and extracts the characteristic roots is applied to the matrix at this point.

A functional flow diagram is presented in Figure 7.3.

7.2 Subroutine DCOSD.

This program computes the $\Delta\alpha$ vector components required by subroutine LAT. The vector components are derived from the generalized formulation in equation 5.4-18.

With x , z , and θ equated to zero for the lateral/directional stability analysis, equation 5.4-18 can be expanded to the following form:

$$\Delta\alpha_1 = \left(-\frac{\cos \alpha_2 \cot \alpha_1}{l} \right) y - \left(\frac{y_p \sin \alpha_1 + x_p \cos \alpha_2 \cot \alpha_1}{l} \right) \psi + \left(\frac{z_p \cos \alpha_2 \cot \alpha_1 - y_p \cos \alpha_2 \cot \alpha_1}{l} \right) \phi \quad (7.2-1)$$

$$\Delta\alpha_2 = \frac{\sin \alpha_2}{l} y + \left(\frac{y_p \cos \alpha_1 \cot \alpha_2 + x_p \sin \alpha_2}{l} \right) \psi - \left(\frac{z_p \sin \alpha_2 + y_p \cos \alpha_3 \cot \alpha_2}{l} \right) \phi \quad (7.2-2)$$

$$\Delta\alpha_3 = \left(-\frac{\cos \alpha_2 \cot \alpha_3}{l} \right) y + \left(\frac{y_p \cos \alpha_1 \cot \alpha_3 - x_p \cos \alpha_2 \cot \alpha_3}{l} \right) \psi + \left(\frac{z_p \cos \alpha_2 \cot \alpha_3 + y_p \sin \alpha_3}{l} \right) \phi \quad (7.2-3)$$

The program thus generates an array of nine elements, three elements for each of the three vectors.

LATERAL DISSECTIONAL CABLE MATRIX

	y	ψ	ϕ	ΔT	$\Delta \alpha_1$	$\Delta \alpha_2$	$\Delta \alpha_3$	Δl
①	$-T \cos \alpha_1$	$T \cos \alpha_3$	$\cos \alpha_2$			$-T \sin \alpha_2$		
②	$-x_p T \cos \alpha_1 - y_p T \sin \alpha_2$	$x_p T \cos \alpha_3$	$y_p \cos \alpha_2 - y_p \cos \alpha_1$	$y_p T \sin \alpha_1$		$-x_p T \sin \alpha_2$		
③	$y_p T \cos \alpha_1 - y_p T \cos \alpha_3 - y_p T \cos \alpha_1$	$y_p \cos \alpha_3 - y_p \cos \alpha_2$	$y_p \cos \alpha_2$	$y_p T \sin \alpha_2$	$y_p T \sin \alpha_3$			
④							AKE	
⑤	$\Delta \alpha_1 \gamma$	$\Delta \alpha_1 \psi$	$\Delta \alpha_1 \phi$		-1			
⑥	$\Delta \alpha_2 \gamma$	$\Delta \alpha_2 \psi$	$\Delta \alpha_2 \phi$			-1		
⑦	$\Delta \alpha_3 \gamma$	$\Delta \alpha_3 \psi$	$\Delta \alpha_3 \phi$				-1	
⑧	Δl_y	Δl_ψ	Δl_ϕ					-1

EQUATIONS: ① $\Delta F_{T_2} = \Delta F_{T_1} - F_{T_{01}} \psi + F_{T_{03}} \phi = (T \cos \alpha_2 - \Delta \alpha_1 T \sin \alpha_2) - T \cos \alpha_1 \psi + T \cos \alpha_3 \phi$ (eq 7.1-4)

$$\begin{aligned} ② \quad \Delta N_T &= (x_p \Delta F_{T_2} - y_p \Delta F_{T_1}) - (x_p F_{T_{01}} + y_p F_{T_{02}}) \psi + x_p F_{T_{03}} \phi = [x_p (\Delta T \cos \alpha_2 - \Delta \alpha_1 T \sin \alpha_2) - y_p (\Delta T \cos \alpha_1 - \Delta \alpha_1 T \sin \alpha_1)] \\ &\quad - [x_p T \cos \alpha_1 + y_p T \cos \alpha_2] \psi + x_p T \cos \alpha_3 \phi \quad (\text{eq 7.1-4}) \end{aligned}$$

$$\begin{aligned} ③ \quad \Delta L_I &= (y_p \Delta F_{T_3} - z_p \Delta F_{T_2}) + z_p F_{T_{01}} \psi - (y_p F_{T_{02}} + z_p F_{T_{03}}) \phi = [y_p (\Delta T \cos \alpha_3 - \Delta \alpha_2 T \sin \alpha_3) - z_p (\Delta T \cos \alpha_2 - \Delta \alpha_3 T \sin \alpha_2) \\ &\quad + z_p T \cos \alpha_1 \psi - [y_p T \cos \alpha_2 + z_p T \cos \alpha_3] \phi] \quad (\text{eq 7.1-4}) \end{aligned}$$

$$④ \quad \Delta T_F = 0 \quad , \quad \Delta T_R = AKE (\Delta l_3 + \Delta l_4) \quad (\text{eq 7.1-5})$$

$$⑤ \quad \Delta \alpha_1 = \Delta \alpha_1 \gamma \gamma + \Delta \alpha_1 \psi \psi + \Delta \alpha_1 \phi \phi \quad (\text{eq 7.2-1})$$

$$⑥ \quad \Delta \alpha_2 = \Delta \alpha_2 \gamma \gamma + \Delta \alpha_2 \psi \psi + \Delta \alpha_2 \phi \phi \quad (\text{eq 7.2-2})$$

$$⑦ \quad \Delta \alpha_3 = \Delta \alpha_3 \gamma \gamma + \Delta \alpha_3 \psi \psi + \Delta \alpha_3 \phi \phi \quad (\text{eq 7.2-3})$$

$$⑧ \quad \Sigma l = \Delta l_y \gamma + \Delta l_\psi \psi + \Delta l_\phi \phi = (\Delta l_{3\gamma} + \Delta l_{4\gamma}) \gamma + (\Delta l_{3\psi} + \Delta l_{4\psi}) \psi + (\Delta l_{3\phi} + \Delta l_{4\phi}) \phi \quad (\text{eq 7.2-4})$$

FIG. 7.1 - MATRIX

LATERAL DIRECTIONAL CHARACTERISTICS MATRIX EQUATIONS

γ	ψ	ϕ
$m\ddot{\gamma} = \left(\frac{\partial Y_A}{\partial \beta} \frac{1}{V_0} + \frac{\partial Y_{cg}}{\partial \gamma} \right) A - \frac{\partial Y_c}{\partial \phi}$	$m X_{cg} A^2 - \left(\frac{\partial Y_c}{\partial r} + \frac{\partial Y_{sn}}{\partial r} \right) A + \left(\frac{\partial Y_A}{\partial r} - \frac{\partial Y_c}{\partial \psi} - W \sin \theta_0 \right)$	$-m Z_{cg} A^2 - \left(\frac{\partial Y_c}{\partial p} + \frac{\partial Y_{sn}}{\partial p} \right) A - \left(\frac{\partial Y_c}{\partial \phi} + W \cos \theta_0 \right)$
$m\ddot{\psi} = \left(\frac{\partial N_A}{\partial \beta} + \frac{\partial L_{sn}}{\partial \gamma} \right) A - \frac{\partial L_c}{\partial \phi}$	$I_{zz} \ddot{\psi}^2 - \left(\frac{\partial N_A}{\partial r} + \frac{\partial L_{sn}}{\partial r} \right) A + \left(\frac{\partial L_A}{\partial r} - \frac{\partial L_c}{\partial \psi} - X_{cg} W \sin \theta_0 \right)$	$-I_{zz} \ddot{\psi}^2 - \left(\frac{\partial N_c}{\partial \phi} + \frac{\partial L_{sn}}{\partial \phi} \right) A - \left(\frac{\partial N_c}{\partial \phi} - X_{cg} W \cos \theta_0 \right)$

Y-Force Equation:

$$m\ddot{y} = \frac{\partial Y_A}{\partial r} \beta + \frac{\partial Y_A}{\partial r} \dot{\beta} + \frac{\partial Y_c}{\partial p} \dot{\psi} + m Z_{cg} \dot{\psi} + m X_{cg} \dot{\phi} + \frac{\partial Y_c}{\partial \psi} \dot{\psi} + \frac{\partial Y_c}{\partial \phi} \dot{\phi} + \frac{\partial Y_{sn}}{\partial \phi} \dot{\phi}$$

$$\text{Weight} \quad \frac{m\ddot{y}}{Aero} \quad \frac{Cable Spring Force}{Weight} \quad \frac{Cable Damping Moment}{Weight} \quad \frac{Surface Damping Force}{Weight}$$

$$m\ddot{\psi} = I_{zz} \ddot{\psi} + \frac{\partial N_A}{\partial r} \beta + X_{cg} (\beta \sin \theta_0 - W \cos \theta_0) - m X_{cg} \dot{\beta} + \frac{\partial N_c}{\partial \phi} \dot{\psi} + \frac{\partial N_{sn}}{\partial \phi} \dot{\psi} + \frac{\partial N_{sw}}{\partial \phi} \dot{\psi} + \frac{\partial N_{sw}}{\partial \phi} \dot{\phi}$$

$$\text{Weight} \quad \frac{m\ddot{\psi}}{Aero Moment} \quad \frac{Cable Spring Moment}{Weight Moment} \quad \frac{Cable Damping Moment}{Weight Moment} \quad \frac{Surface Damping Moment}{Weight Moment}$$

Roll Moment Equation:

$$I_{xx} \ddot{\phi} - I_{zz} \dot{\psi}^2 = \frac{\partial N_A}{\partial r} \beta + \frac{\partial L_A}{\partial r} \dot{\beta} + \frac{\partial L_A}{\partial \phi} \dot{\phi} + X_{cg} (W \cos \theta_0 + W \sin \theta_0) + m Z_{cg} \dot{\beta} + \frac{\partial L_c}{\partial \phi} \dot{\phi} + \frac{\partial L_{sn}}{\partial \phi} \dot{\phi} + \frac{\partial L_{sw}}{\partial \phi} \dot{\phi}$$

$$\text{Weight} \quad \frac{m\ddot{\phi}}{Aero Moment} \quad \frac{Cable Spring Moment}{Weight Moment} \quad \frac{Cable Damping Moment}{Weight Moment} \quad \frac{Surface Damping Moment}{Weight Moment}$$

Auxiliary Equation:

$$\beta = \psi + \frac{\dot{\phi}}{\dot{\beta}}$$

$$\dot{\beta} = \dot{\psi} + \frac{\dot{\phi}}{\dot{\beta}}$$

FIG. 7.2 - MATRIX

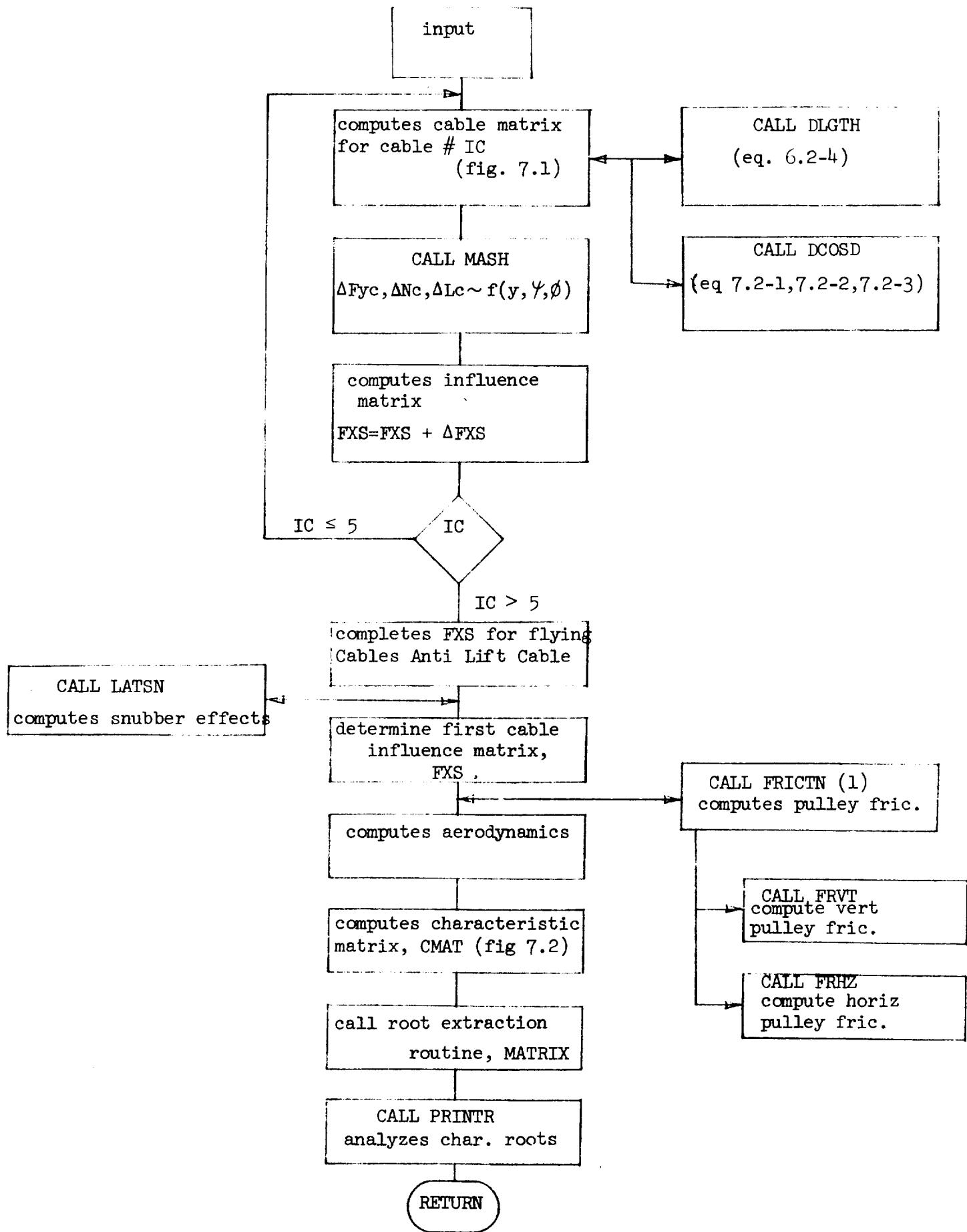


FIGURE 7.3 - FLOW CHART - SUBROUTINE LAT.

8.0 MODELING SNUBBER EFFECTS

8.1 SNUBBER SNUBBED EFFECTS

8.1.1 TRIM EFFECTS

The effects of the snubbers on model trim are introduced as FXSN, FZSN and AMSN into the TRIM subroutine. These terms are calculated in subroutine SNTRM. The expressions for modeling these effects are identical to those used for the flying cables. The direction cosines for each snubber cable are generated in subroutine DRSCN with the resulting force and moment contributions being defined in terms of these angles.

The following derivation of one set of direction cosines for the upper right cable applies to all snubber cables. See Figure 11.3 for a definition of terms.

Calculate linear components from equation reference center to snubber tie down at the tunnel wall:

$$X_{T_1} = STACR - SNUST$$

$$Z_{T_1} = WLCR - SNUWL$$

$$Y_{T_1} = - SNUBL$$

transforming to body axis:

$$X_{B_1} = X_{T_1} \cos \theta - Z_{T_1} \sin \theta$$

$$Z_{B_1} = X_{T_1} \sin \theta + Z_{T_1} \cos \theta$$

$$Y_{B_1} = Y_{T_1}$$

Finding linear components from model tie down point to tunnel side wall:

$$X_B = X_{B_1} + SNUX$$

$$Y_B = Y_{B_1} + SNUY$$

$$Z_B = Z_{B_1} + SNUZ$$

The linear distance is then:

$$L = \sqrt{X_B^2 + Y_B^2 + Z_B^2}$$

The direction cosines are:

$$\gamma_x = X_B/L \quad \gamma_y = Y_B/L \quad \gamma_z = Z_B/L$$

resulting in the angles being:

$$\alpha_x = \cos^{-1} \gamma_x, \quad \alpha_y = \cos^{-1} \gamma_y, \quad \alpha_z = \cos^{-1} \gamma_z$$

Assuming top and bottom cables to be symmetric with respect to the X-Z plane, the following force and moment equations define the terms necessary to determine trim.

$$F_{X_{up}} = 2 T_{up} \cos \alpha_{x_u}$$

$$F_{X_{low}} = 2 T_{low} \cos \alpha_{x_1}$$

$$F_{Z_{up}} = 2 T_{up} \cos \alpha_{z_u}$$

$$F_{Z_{low}} = 2 T_{low} \cos \alpha_{z_1}$$

$$M_{up} = (-SNUZ) F_{X_{up}} + (SNUX) F_{Z_{up}} \quad M_{low} = (SNLZ) F_{X_{low}} + (SNLX) F_{Z_{low}}$$

or:

$$F_x = F_{x_{up}} + F_{x_{low}} = FXSN$$

$$F_z = F_{z_{up}} + F_{z_{low}} = FZSN$$

$$M = M_{up} + M_{low} = AMSN$$

A flow chart of subroutine SNTRM is shown in Figure 8.1.

8.1.2

STABILITY EFFECTS

The effects of the snubbed snubbers on both longitudinal and lateral stability are modeled similar to the rear flying cables. These effects are calculated in subroutines LONGSN and LATSN and inserted into subroutines LONG and LAT as additional terms (SNU, SNUD) in the polynomial matrix describing the system. Each cable is modeled independently, the terms effecting each cable are summed up and the results, contained in the SNU array, are combined with the flying cable effects in the CMAT array. Since the theoretical derivation of these terms is similar to the rear flying cables, the derivation here will be abbreviated.

The major difference in the derivation is the calculation of the change in tension. For the rear flying cables the cable tension change was defined as:

$$\Delta T = K \Delta L$$

The snubber cables have an added damping effect resulting in the following equation:

$$\Delta T = K \Delta L + D \Delta L$$

The damping term is added to the polynomial matrix CMAT through the array SNUD.

Flow charts for subroutines LONGSN and LATSN are shown in Figures 8.2 and 8.3.

8.1.2.1 LONGITUDINAL STABILITY EFFECTS

Due to symmetry the longitudinal effects of the top snubbers are modelled simultaneously and similarly the bottom cables can be modelled together. Only the top cable derivation will be presented here. See Figure 11.3 for a pictorial representation of the snubbers.

The total force and moment equations from Section 5.0 are:

$$\Sigma F_x = 2(T + \Delta T) \cos(\alpha_x + \Delta\alpha_x) - (2T \cos\alpha_z) \theta$$

$$\Sigma F_z = 2(T + \Delta T) \cos(\alpha_z + \Delta\alpha_z) + (2T \cos\alpha_x) \theta$$

$$\Sigma M = (SNUZ)(-F_x) + (SNUX)F_z$$

Defining perturbation terms:

$$\Delta T = K \Delta L + D \dot{\Delta L}$$

and from Section 5.0:

$$\begin{aligned} \Delta\alpha_x &= \left[\frac{-SNUX \sin \alpha_x}{ALU} + \left(\frac{-SNUX}{ALU} \right) \cos \alpha_z \cot \alpha_x \right] \theta \\ &\quad + \left[\frac{\sin \alpha_x}{ALU} \right]_x + \left[\frac{-\cos \alpha_z \cot \alpha_x}{ALU} \right] z \\ \Delta\alpha_z &= \left[\frac{SNUZ \cos \alpha_x \cot \alpha_z}{ALU} + \left(\frac{-SNUX}{ALU} \right) \sin \alpha_z \right] \theta + \left[\frac{\sin \alpha_z}{ALU} \right] z \\ &\quad + \left[\frac{-\cos \alpha_x \cot \alpha_z}{ALU} \right] x \\ \Delta L &= \left[-\cos \alpha_x \right]_x + \left[(-SNUX + (ALU) \cos \alpha_x) \cos \alpha_z \right. \\ &\quad \left. - (-SNUZ + (ALU) \cos \alpha_z) \cos \alpha_x \right] \theta - \left[\cos \alpha_z \right] z \end{aligned}$$

These equations are set in a 7×7 matrix with the following form:

$$\begin{bmatrix} \Sigma F_x \\ \Sigma F_z \\ \Sigma M \\ -1 & & & & & & \\ & -1 & & & & & \\ & & -1 & & & & \\ & & & -1 & & & \end{bmatrix} \begin{bmatrix} x \\ z \\ \theta \\ \Delta\alpha_x \\ \Delta\alpha_z \\ \Delta T \\ \Delta L \end{bmatrix} = 0$$

This matrix is reduced to a 3 x 3 matrix in x, z and θ . The first order terms are contained in the 3 x 3 array FTOP and the damping terms (second order) are contained in the array SNUD.

A similar procedure is followed for the effects of the bottom cables. The terms for each set of cables are then combined and added to the longitudinal stability matrix through the arrays SNU and SNUD.

8.1.2.2 LATERAL STABILITY EFFECTS

The lateral stability effects of the snubbers are modeled for each cable individually and the results summed up. The procedure is similar to the longitudinal case. Only the top right cable terms will be shown here. The effects for the other cables are similar.

Force and moment equations are:

$$\begin{aligned} F_y &= (T + \Delta T) \cos(\alpha_y + \Delta\alpha_y) - (T \cos \alpha_x) \Psi + (T \cos \alpha_z) \phi \\ \Sigma N &= (-SNUX) F_y + (SNUY) F_x \\ \Sigma L &= (-SNUY) F_z + (SNUZ) F_y \end{aligned}$$

expanding the equations and dropping the steady state terms:

$$\begin{aligned} \Sigma \Delta F_y &= \Delta T \cos \alpha_y - T \sin \alpha_y \Delta \alpha_y - \Psi T \cos \alpha_x + T \cos \alpha_z \phi \\ \Sigma \Delta N &= (-SNUX) \Delta F_y + SNUY \left[\Delta T \cos \alpha_x - T \sin \alpha_x \Delta \alpha_x \right] \\ \Sigma \Delta L &= (SNUZ) \Delta F_y - SNUY \left[\Delta T \cos \alpha_z - T \sin \alpha_z \Delta \alpha_z \right] \end{aligned}$$

Defining ΔT , ΔL , $\Delta \alpha_x$, $\Delta \alpha_y$, $\Delta \alpha_z$:

$$\Delta T = K \Delta \ell + D \Delta \dot{\ell}$$

From Section 5.0:

$$\Delta l = \left[-\cos \alpha_y \right] Y + \left[(-SNUZ) \cos \alpha_y + (SNUY) \cos \alpha_z \right] \phi + \left[(-SNUY) \cos \alpha_x + (SNUX) \cos \alpha_y \right] \psi$$

$$\Delta \alpha_x = \left[\frac{(-SNUY) \sin \alpha_x - (SNUX) \cos \alpha_y \cot \alpha_x}{ALU} \right] \psi$$

$$+ \left[\frac{(-SNUZ) \cos \alpha_y \cot \alpha_x + SNUY \cos \alpha_z \cot \alpha_x}{ALU} \right] \phi + \left[\frac{-\cos \alpha_y \cot \alpha_x}{ALU} \right] y$$

$$\Delta \alpha_y = \left[\frac{(-SNUY) \cos \alpha_y \cot \alpha_y - (SNUX) \sin \alpha_y}{ALU} \right] \psi + \left[\frac{\sin \alpha_y}{ALU} \right] y - \left[\frac{(-SNUZ) \sin \alpha_y - (SNUY) \cos \alpha_z \cot \alpha_y}{ALU} \right] \phi$$

$$\Delta \alpha_z = \left[\frac{(-SNUY) \cos \alpha_x \cot \alpha_z + (SNUX) \cos \alpha_y \cot \alpha_z}{ALU} \right] \psi + \left[\frac{(-SNUZ) \cos \alpha_y \cot \alpha_z - (SNUY) \sin \alpha_z}{ALU} \right] \phi - \left[\frac{\cos \alpha_y \cot \alpha_z}{ALU} \right] y$$

These equations are set in a 8×8 matrix with the following form:

$$\begin{bmatrix} \Sigma F_y & & & & & & & \\ \Sigma \Delta N & & & & & & & \\ \Sigma \Delta L & & & & & & & \\ -1 & & & & & & & \\ & -1 & & & & & & \\ & & -1 & & & & & \\ & & & -1 & & & & \\ & & & & -1 & & & \end{bmatrix} \begin{bmatrix} y \\ \psi \\ \phi \\ \Delta \alpha_x \\ \Delta \alpha_y \\ \Delta \alpha_z \\ \Delta T \\ \Delta l \end{bmatrix} = 0$$

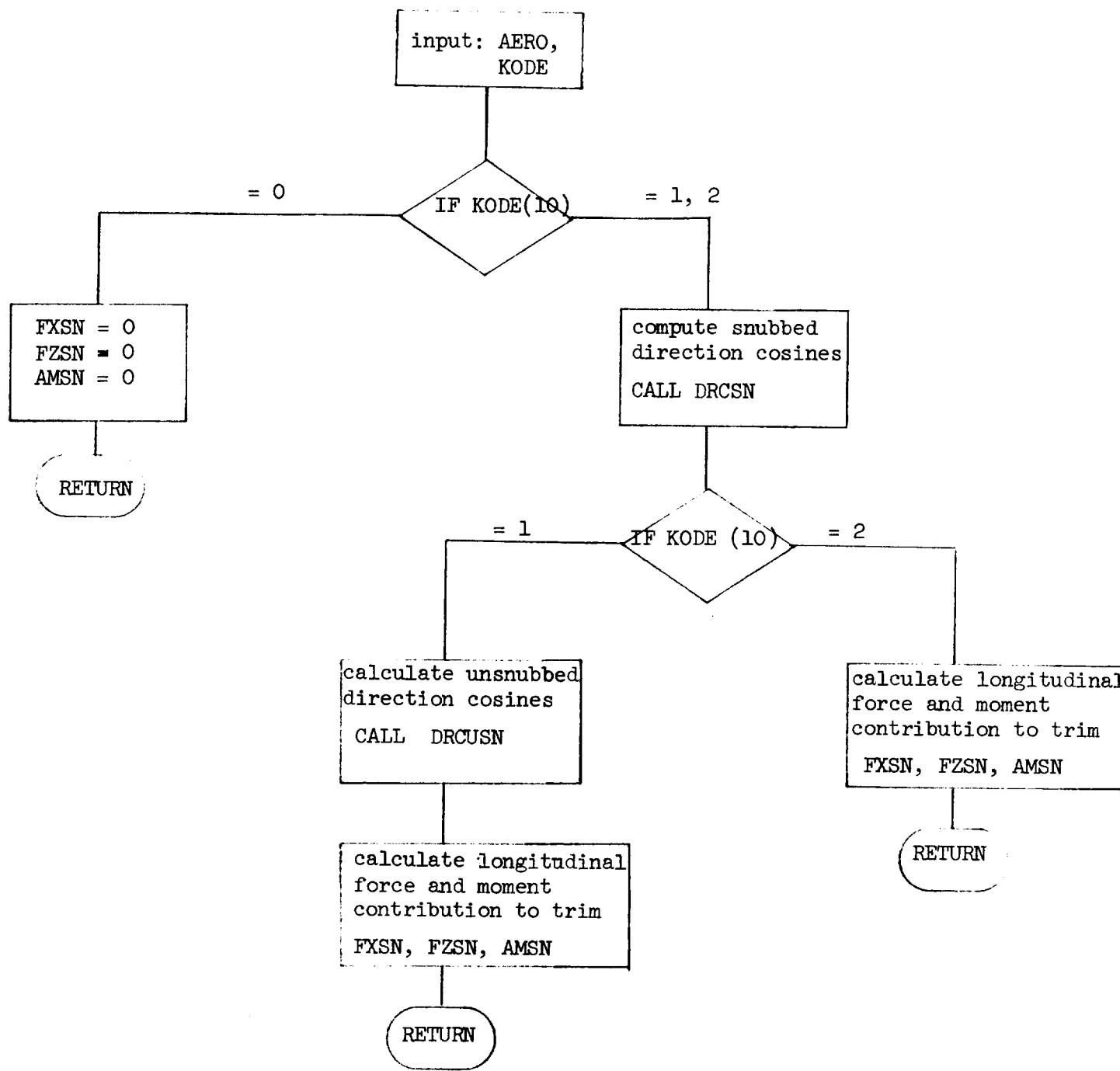


FIGURE 8.1 - FLOW CHART - SUBROUTINE SNTRM

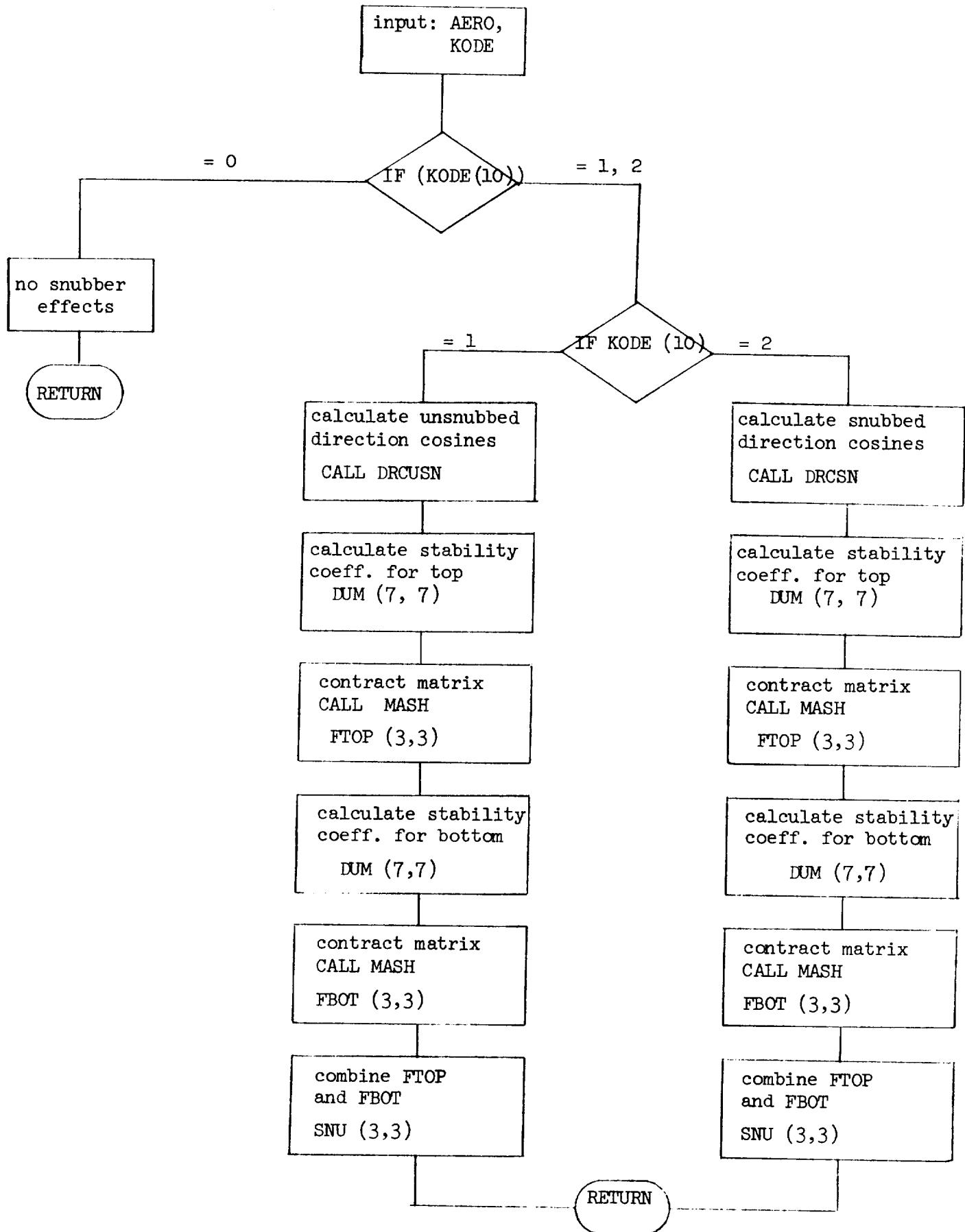


FIGURE 8.2 - FLOW CHART - SUBROUTINE LONGSN

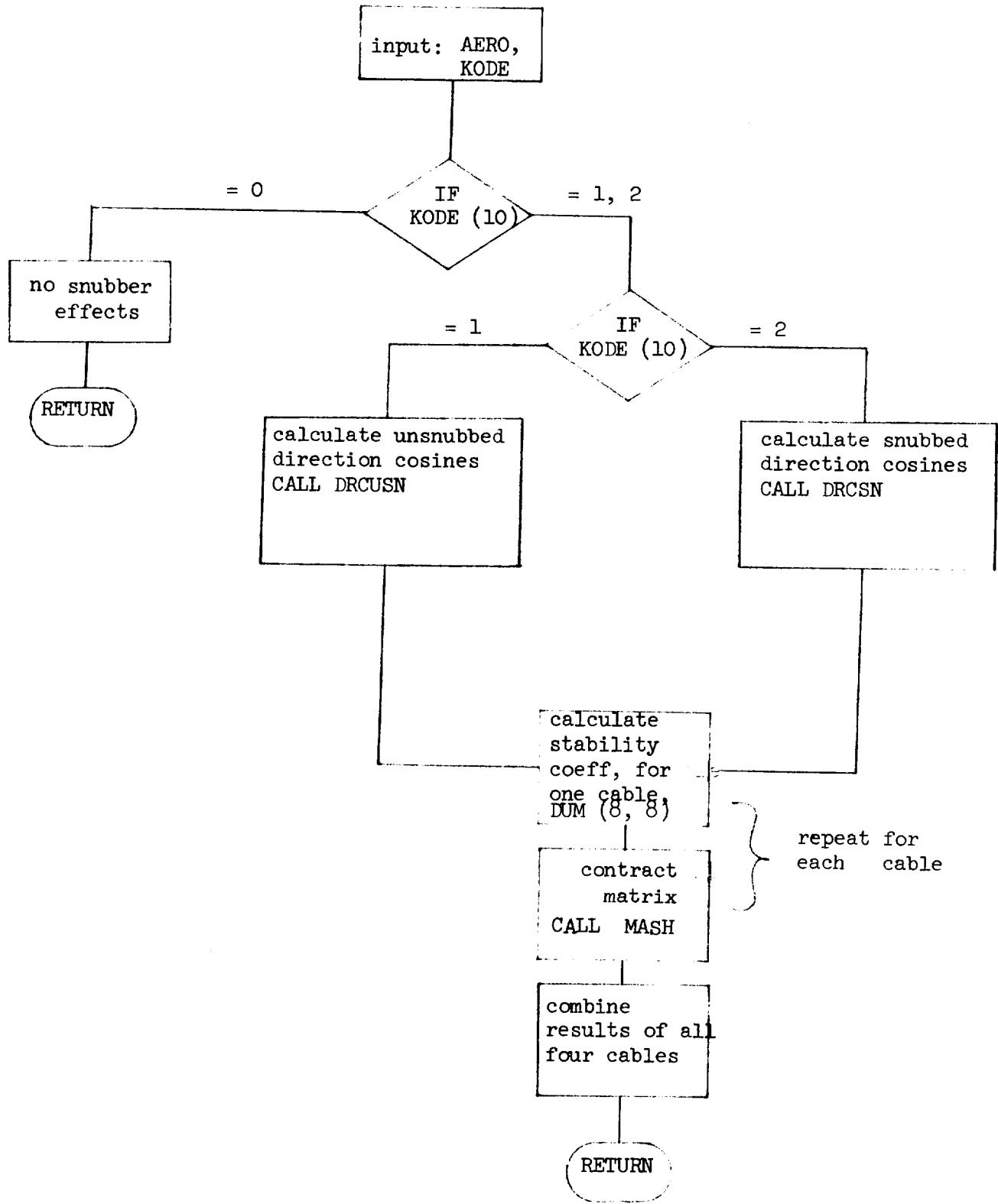


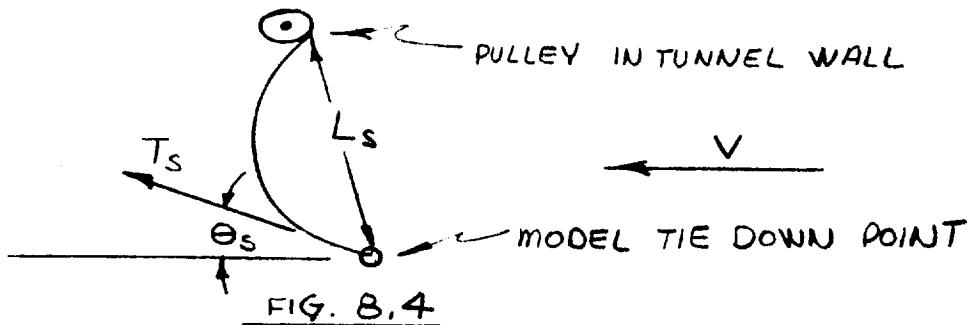
FIGURE 8.3 - FLOW CHART - SUBROUTINE LATSN

This matrix is reduced to a 3×3 matrix in y , Ψ and ϕ . A similar procedure is used to derive the contributions of the other three cables. The effects of all cables are added and introduced in the lateral stability matrix as SNU and SNUD.

8.2 UNSNUBBED SNUBBER EFFECTS

8.2.1 TRIM EFFECTS

The effects of the unsnubbed snubbers are modeled similar to the snubbed case except for the calculation of the direction cosines and the effective spring constant for each cable. The direction cosines for each slack cable are calculated in subroutine DRCUSN using the data from Table 1. This table contains a record of the true angle (θ_s) between the unsnubbed cable at the model tie down point and the tunnel negative X axis vs. dynamic pressure and linear distance (L_s) between model and tunnel wall tie down points. This function is shown graphically below.



L_s = true linear distance between the model tie-down and side wall pulley.

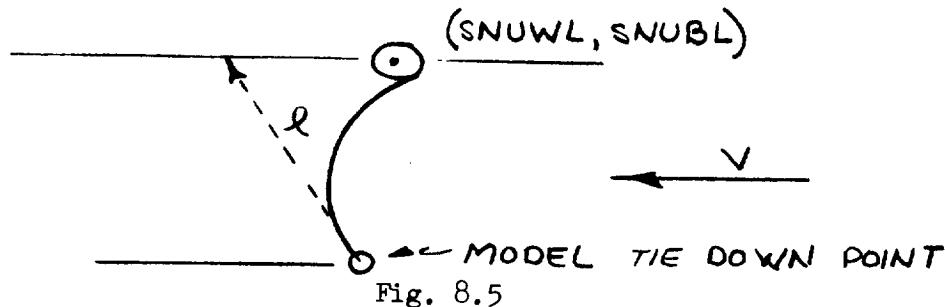
θ_s = angle made between the slack cable and the tunnel centerline.

T_s = tension in cable at tie-down point.

The direction cosines are derived below for the top right snubber in the unsnubbed condition. The other three cables are similarly derived. Referring to Figure 8.4, the angle the cable makes with the X-axis is:

$$\alpha_x = -\cos^{-1}(\theta_s)$$

The Y and Z axis angles are derived from the theoretical length of a vector originating at the model tie-down point, intercepting the tunnel side wall and running parallel to the force vector shown below.

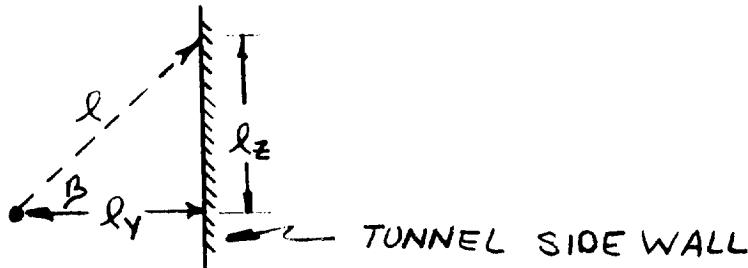


The Y and Z components of this vector are:

$$l_z = SNUWL - (WLCR + SNUZ - SNUX \cdot \sin \theta)$$

$$l_y = SNUBL - (BLCR + SNUY)$$

A front view of this vector shows:



from which: $\theta = \tan^{-1} l_z / l_y$

The theoretical length of the vector is then:

$$l = l_y / (\sin \theta_s) (\cos \beta)$$

which implies the direction cosines are:

$$\gamma_y = l_y / l \quad \alpha_y = \cos^{-1} \gamma_y$$

$$\gamma_z = l_z / l \quad \alpha_z = \cos^{-1} \gamma_z$$

These angles are in the tunnel axis system, converting to model body axis:

$$\alpha_{x_1} = \alpha_x \cos \theta - \alpha_z \sin \theta$$

$$\alpha_{y_1} = \alpha_y$$

$$\alpha_{z_1} = \alpha_z \cos \theta + \alpha_x \sin \theta$$

Since top and bottom cables are symmetric with respect to the X-Z plane, the equations shown in Section 8.1.1 can be used once again to describe the longitudinal force and moment contributions to trim.

$$F_x = 2 T_s \cos \alpha_x$$

$$F_z = 2 T_s \cos \alpha_z$$

$$M = (-SNUX) F_x + (SNUX) F_z$$

The tension (T_s) as a function of dynamic pressure and length (L_s) is contained in Table 2.

8.2.2 STABILITY EFFECTS

The effects of the unsnubbed snubbers on longitudinal and lateral/directional stability are modeled exactly as the snubbed case using the direction cosines derived in the previous section. The effective spring constant is calculated by obtaining the local slope of the change in tension (T_s) per change in length (L_s) obtained from Table 2.

$$\Delta T = K \Delta L$$

$$K = \Delta T_s / \Delta L$$

The effects on stability of the unsnubbed snubber are calculated in LONGSN and LATSN and inserted into subroutines LONG and LAT as additional terms (SNU) in the matrices describing the system.

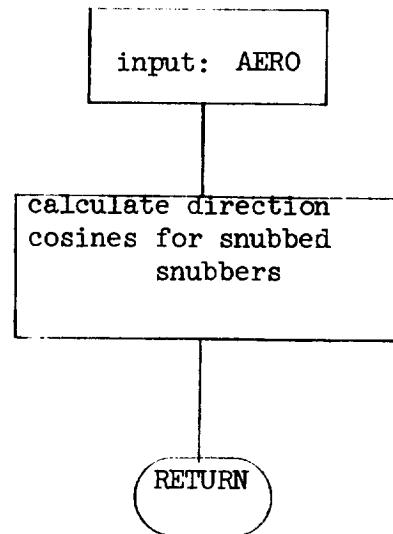
8.2.2.1 LONGITUDINAL STABILITY

Symmetry allows the top cables to be treated together and similarly the bottom cables. The equations are exactly the same as tabulated in Section 8.1.2.1. The direction cosines derived for the slack cable are used in all equations except for the ΔL equation.

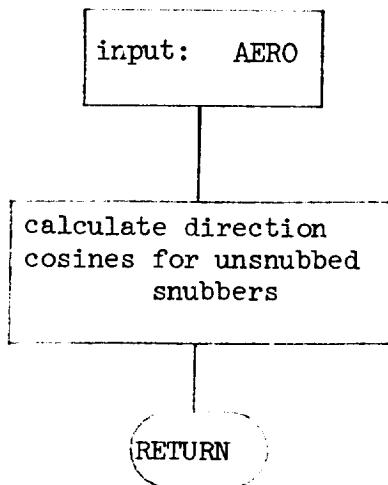
Since the spring constraint is defined in terms of a change in linear distance (L_s), the ΔL must be defined in terms of this length. Therefore the snubbed direction cosines are used for this equation. There are no damping terms ($D \Delta L$) associated with the unsnubbed cable.

8.2.2.2 LATERAL STABILITY

These terms are modeled exactly the same as the snubbed case except for the changes described in the preceding section.



SUBROUTINE DRCSN



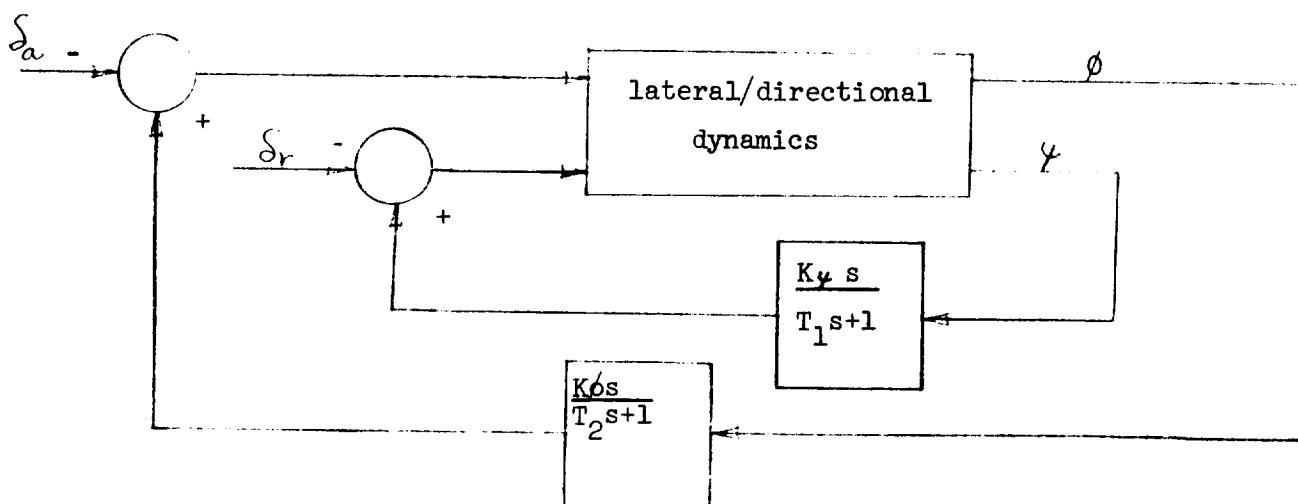
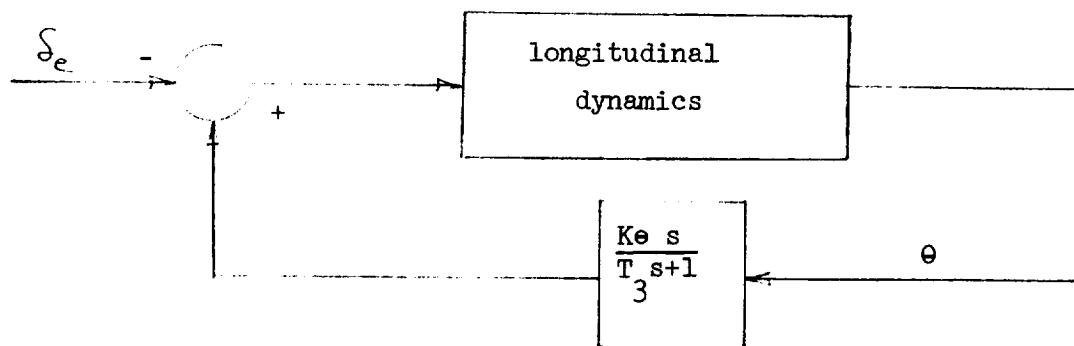
SUBROUTINE DRCUSN

FIGURE 8.6 - FLOW CHART - SUBROUTINE DRCSN, DRCUSN

9.0 DESCRIPTION OF FEEDBACK MODELS

The feedback loops for both the longitudinal and lateral /directional stability analysis are modeled using additional rows and columns in the basic polynomial matrix representation of the dynamics.

The basic feedback elements for which provisions have been made in the program are shown below in block diagram form.



The equations describing the feedbacks are:

$$\delta_e = \frac{K_\theta S}{T_3 S + 1} \theta$$

$$\delta_a = \frac{K_\theta S}{T_1 S + 1} \phi, \quad \delta_r = \frac{K_\psi S}{T_2 S + 1} \psi$$

The basic polynomial matrices are modified as follows to account for the feedback control laws.

Longitudinal:

$$\begin{array}{c}
 \text{BASIC} \\
 \text{MATRIX}
 \end{array}
 \left[\begin{array}{cc}
 & \begin{matrix} -qSC_X \delta_e \\ -qSC_Z \delta_e \\ -qScC_M \delta_e \end{matrix} \\
 \hline
 (T_3 S + 1) & (K_\theta S)
 \end{array} \right] \left[\begin{array}{c} z \\ \theta \\ \Delta T_F \\ x \\ \delta_e \end{array} \right] = 0$$

Lateral/Directional:

$$\begin{array}{c}
 \boxed{\text{BASIC}} \\
 \boxed{\text{MATRIX}} \\
 \hline
 \boxed{K_{\Psi} S} & \boxed{-T_2 S^{-1}} & \boxed{y} \\
 \boxed{-qSbC_{Y\delta_r}} & \boxed{-qSbC_{Y\delta_a}} & \boxed{\Psi} \\
 \boxed{-qSbC_{N\delta_r}} & \boxed{-qSbC_{N\delta_a}} & \boxed{\phi} \\
 \boxed{-qSbC_{\ell\delta_r}} & \boxed{-qSbC_{\ell\delta_a}} & \boxed{\delta_r} \\
 \hline
 \boxed{K_{\phi} S} & \boxed{-T_1 S^{-1}} & \boxed{\delta_a}
 \end{array} = 0$$

The longitudinal control law may be evaluated by setting KODE (8) = 5.

The directional control law may be evaluated by the setting KODE (9) = 5.

The lateral plus directional control laws may be evaluated by setting KODE (9) = 6. If no directional loop is to be evaluated, set AERO (123) and AERO (127) equal to 0.

If no control loops are to be considered then KODE (8) = 4 and KODE (9) = 3.

The basic control laws provided in the program (pitch damping, roll damping and yaw damping) can be modified by manually changing the definition of the elements in the 7×7 array 'CMAT' which defines the linearized system dynamics. The procedure is similar to that outlined above. NOTE: The program is limited to 2nd order polynomials. Higher order terms can be handled using state vector modeling.

10.0 PULLEY FRICTION

The assumption is made that the pulley-cable friction is made up of two parts, rolling friction and coulomb friction. Both rolling and coulomb friction combine to create a change in cable tension around the pulley.

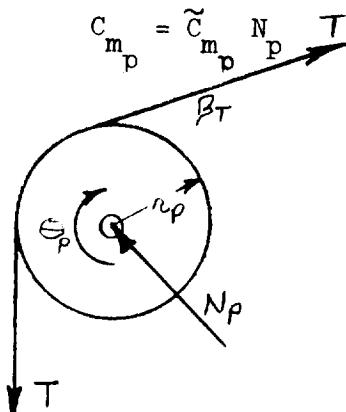
The rolling friction is treated as a linear term and the coulomb friction is linearized using a describing function technique to be described in this section. The terms are calculated in subroutine FRICT and added to the appropriate polynomial matrix through array FRIC.

10.1 ROLLING FRICTION

Rolling friction is described by the rotational damping coefficient, C_{m_p} (ft-#/RPS). The moment transmitted to the model is then:

$$M_{P_R} = \tilde{C}_{m_p} \overset{\circ}{\theta}_p N_p \quad (10.1-1)$$

where $\overset{\circ}{\theta}$ is the pulley rotational speed and N_p is the total normal force acting on the pulley.



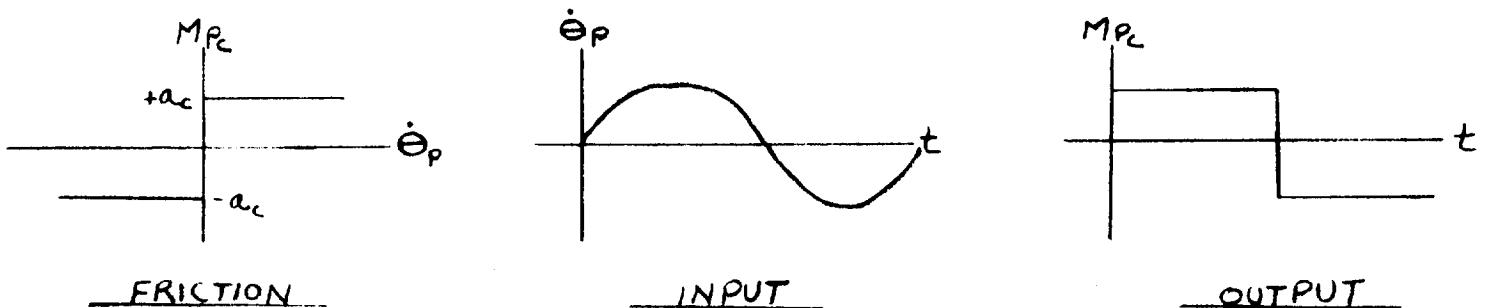
$$N_p = \sqrt{(T - T \sin \beta_T)^2 + (T \cos \beta_T)^2}$$

$$M_{P_R} = \tilde{C}_{m_p} \sqrt{(T - T \sin \beta_T)^2 + (T \cos \beta_T)^2} \dot{\theta}_p$$

10.2 COULOMB FRICTION

Coulomb friction is by definition a non-linear effect where the friction force is of constant magnitude and is always in such a direction as to resist the relative motion. This non-linear effect can be replaced by an 'equivalent' linear effect employing the following reasoning.

First apply a sinusoidal input in $\dot{\theta}_p$ and look at the moment output due to the coulomb friction.



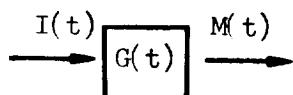
The input can be modeled as:

$$I(t) = \dot{\theta}_p \sin wt$$

The output can be modeled as a Fourier series as follows:

$$M(t) = 4a_c/\pi \left[\sin wt + 1/3 \sin 3wt + 1/5 \sin 5wt \dots \dots \right]$$

In terms of transfer functions we then have:



or:

$$\left[\dot{\theta}_p \sin wt \right] G(t) = 4a_c/\pi \left[\sin wt + 1/3 \sin 3wt + 1/5 \sin 5wt + \dots \right]$$

The equivalent linear transfer function is defined as the ratio of the fundamental mode of the output to the input.

$$G(t) = 4a_c/\pi \sin wt / \dot{\theta}_p \sin wt = 4a_c/\pi \dot{\theta}_p$$

We now have a linear equivalent of the non-linear coulomb friction which is:

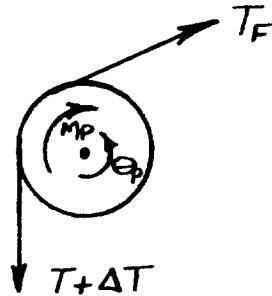
$$M_{p_c} = \frac{4a_c}{\pi} \dot{\theta}_p \quad (10.2-1)$$

a_c is the static opposing force which is a function of wrap angle and normal force. This relationship is empirical and will not be defined in the program. a_c will be input as a constant (AERO (96)) which the user will have to determine.

Combining rolling and coulomb friction, we have the following expression for the total moment.

$$M_p = \left[\tilde{C}_{M_p} N_p \right] \dot{\theta}_p + \left[\frac{4a_c}{\pi} \right] \dot{\theta}_p \quad (10.2-2)$$

Following the reasoning presented by R. M. Bennett in his write-up, 'Comment On Mount System Damping Based On Pulley Rolling Friction,' the total moment transmitted to the model (M_p) creates an unbalance in cable tension around the pulley.



assuming pulley inertia to be negligible, a moment balance produces:

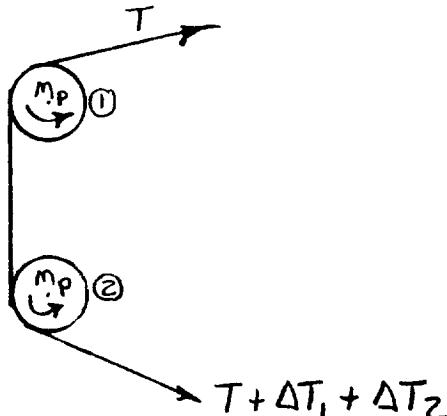
$$\Delta T = M_p / r_p = \left[\tilde{C}_{M_p} N_p / r_p \right] \dot{\theta}_p + \left[\frac{4a_c}{\pi r_p} \right] \dot{\theta}_p \quad (10.2-3)$$

The resulting forces and moments on the model can now be derived using Bennett's equations.

10.3 PULLEY FRICTION EFFECTS ON LONGITUDINAL AND LATERAL/DIRECTIONAL STABILITY

Only vertical pulleys will effect longitudinal stability.

Derivations for both front and rear vertical pulleys follow.



Front Pulley

taking moments around top pulley:

$$\Sigma M = 0$$

$$\Delta T_{r_p} + M_p = 0$$

$$\Delta T_{r_p} - \tilde{C}_{M_p} N_p \dot{\theta}_p - (4a_c/\pi) \theta_p = 0$$

$$\Delta T = \left(\tilde{C}_{M_p} N_p / r_p \right) \dot{\theta}_p + \left(4a_c / \pi r_p \right) \theta_p$$

the pulley rolling in terms of cable length is:

$$\theta_{p_1} = - \Delta \ell_1 / r_p \quad \therefore \quad \theta_{p_2} = - \Delta \ell_1 / r_p$$

$$\dot{\theta}_{p_1} = - \Delta \dot{\ell} / r_p$$

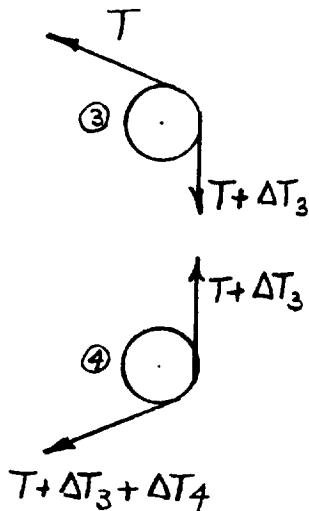
$$\Delta T_{F_1} = \left(\tilde{C}_{M_p} N_p / r_p^2 \right) (-\Delta \ell_1) + \left(4a_c / \pi r_p^2 \right) (-\Delta \ell_1) \quad (10.3-1)$$

a similar approach with the bottom cables yields:

$$\Delta T_{F_2} = \left(\tilde{C}_{M_p} N_p / r_p^2 \right) (\Delta \dot{\ell}_2) + \left(4a_c / \pi r_p^2 \right) (\Delta \ell_2) \quad (10.3-2)$$

$$\therefore \Delta T_{FRONT} = \Delta T_{F_1} + \Delta T_{F_2} = \left(C_{M_p} N_p / r_p^2 \right) \left(\Delta \dot{\ell}_2 - \Delta \dot{\ell}_1 \right) + \left(4a_c / \pi r_p^2 \right) \left(\Delta \ell_2 - \Delta \ell_1 \right) \quad (10.3-3)$$

REAR PULLEY



$$\Sigma M = 0 - \Delta T_{r_p} + M_p = 0$$

$$\Delta T_R = M_p/r_p = -\tilde{C}_{M_p} N_p \dot{\theta}_p/r_p - 4a_c \theta_p/\pi r_p$$

$$\dot{\theta}_p = \Delta \ell_3/r_p \quad \dot{\theta}_p = \Delta \dot{\ell}_3/r_p$$

$$\Delta T_3 = \left(-\tilde{C}_{M_p} N_p/r_p^2 \right) \Delta \dot{\ell}_3 - \left(4a_c/\pi r_p^2 \right) \Delta \ell_3 \quad (10.3-5)$$

$$\Delta T_4 = \left(\tilde{C}_{M_p} N_p/r_p^2 \right) \Delta \dot{\ell}_4 + \left(4a_c/\pi r_p^2 \right) \Delta \ell_4 \quad (10.3-6)$$

$$\therefore \Delta T_{REAR} = \left(\tilde{C}_{M_p} N_p/r_p^2 \right) \left(\Delta \dot{\ell}_4 - \Delta \dot{\ell}_3 \right) + \left(4a_c/\pi r_p^2 \right) (\Delta \ell_4 - \Delta \ell_3) \quad (10.3-7)$$

Since the tension ΔT_{Front} , ΔT_{Rear} is going to act at either the top or the bottom pulley (depending on the direction of motion); and since the arms and direction cosine are inherently different, the effect of these friction contributions is discontinuous about the trim for \pm perturbations in x , z and θ . To eliminate the difficulty, an average arm and direction cosine in the position quadrant is assumed for the action of the forces and moments.

The average direction cosine angles for the front vertical pulleys are:

$$\alpha_x = (\alpha_{21} - \alpha_{11})/2 \quad \alpha_z = \pi/2 - \alpha_x \quad (10.3-8)$$

The average arms for the front vertical pulleys are:

$$\ell_x = (\ell_{1x} - \ell_{1z})/2 \quad \ell_z = (\ell_{2z} - \ell_{1z})/2 \quad (10.3-9)$$

The corresponding set for the rear vertical pulley is:

$$\alpha_x = (\alpha_{41} - \alpha_{31})/2 \quad \ell_x = (\ell_{3x} + \ell_{4x})/2 \quad (10.3-10)$$

$$\alpha_z = \pi/2 - \pi_x \quad \ell_z = (\ell_{4z} - \ell_{3z})/2 \quad (10.3-11)$$

The friction contribution to the ΔF_x , ΔF_z and ΔM for a front and rear vertically configured pulley can be determined.

$$\Delta F_x = \Delta T_{FRONT} \cos \alpha_{x_F} + \Delta T_{REAR} \cos \alpha_{x_R} \quad (10.3-12)$$

$$\Delta F_z = \Delta R_{FRONT} \cos \alpha_{z_F} + \Delta T_{REAR} \cos \alpha_{z_R} \quad (10.3-13)$$

$$\Delta M_y = \Sigma M_p + \Delta F_x \ell_z - \Delta F_z \ell_x \quad (10.3-14)$$

$$\Sigma M_p = M_{p_F} + M_{p_R}$$

$$M_{p_F} = \left(\tilde{C}_{M_p} N_p / r_p \right) (\dot{\Delta \ell}_2 - \dot{\Delta \ell}_1) + \left(4a_c / \pi r_p \right) (\Delta \ell_2 - \Delta \ell_1)$$

$$M_{p_R} = \left(\tilde{C}_{M_p} N / r_p \right) (\dot{\Delta \ell}_4 - \dot{\Delta \ell}_3) + \left(4a_c / \pi r_p \right) (\Delta \ell_4 - \Delta \ell_3)$$

If either front or rear pulleys are horizontal, there are no friction effects modeled for longitudinal analysis.

Similar expressions can be defined for the front and rear tensions for the lateral/directional analysis. In this case, however, the horizontal pulley configurations are the prime contributor to the perturbation dynamics. The horizontal pulley in the trim condition are symmetric about the x-z plane. Thus, the averaging for the direction cosine and arms process required in the longitudinal analyses are not required in the lateral analysis.

$$\Delta F_y = \Delta T_F \cos \alpha_{2F} + \Delta T_R \cos \alpha_{2R}$$

$$\Delta L = \Sigma y F_z - z F_y + L_p \quad (10.3-15)$$

$$\Delta N = \Sigma x F_y - y F_x + N_p$$

where

$$L_p = \sum_{\substack{n=1 \\ F+R}}^2 \frac{C_m}{r_p^2} \dot{\Delta \ell}_n - \dot{\Delta \ell}_{2n} + \frac{4a_c}{\pi r_p^2} (\Delta \ell_n - \Delta \ell_{2n})$$

$$N_p = \sum_{\substack{n=1 \\ F+R}}^2 \frac{C_m}{r_p^2} \dot{\Delta \ell}_n - \dot{\Delta \ell}_{2n} + \frac{4a_c}{\pi r_p^2} (\Delta \ell_n - \Delta \ell_{2n})$$

Flow diagrams for subroutines FRICT, FRVT, FRHZ are shown in Figures 10.1 through 10.3. Subroutine FRKT contains the logic determining which configuration is to be analyzed while subroutines FRVT and FRHZ calculate the friction effects for vertical and horizontal configurations respectively.

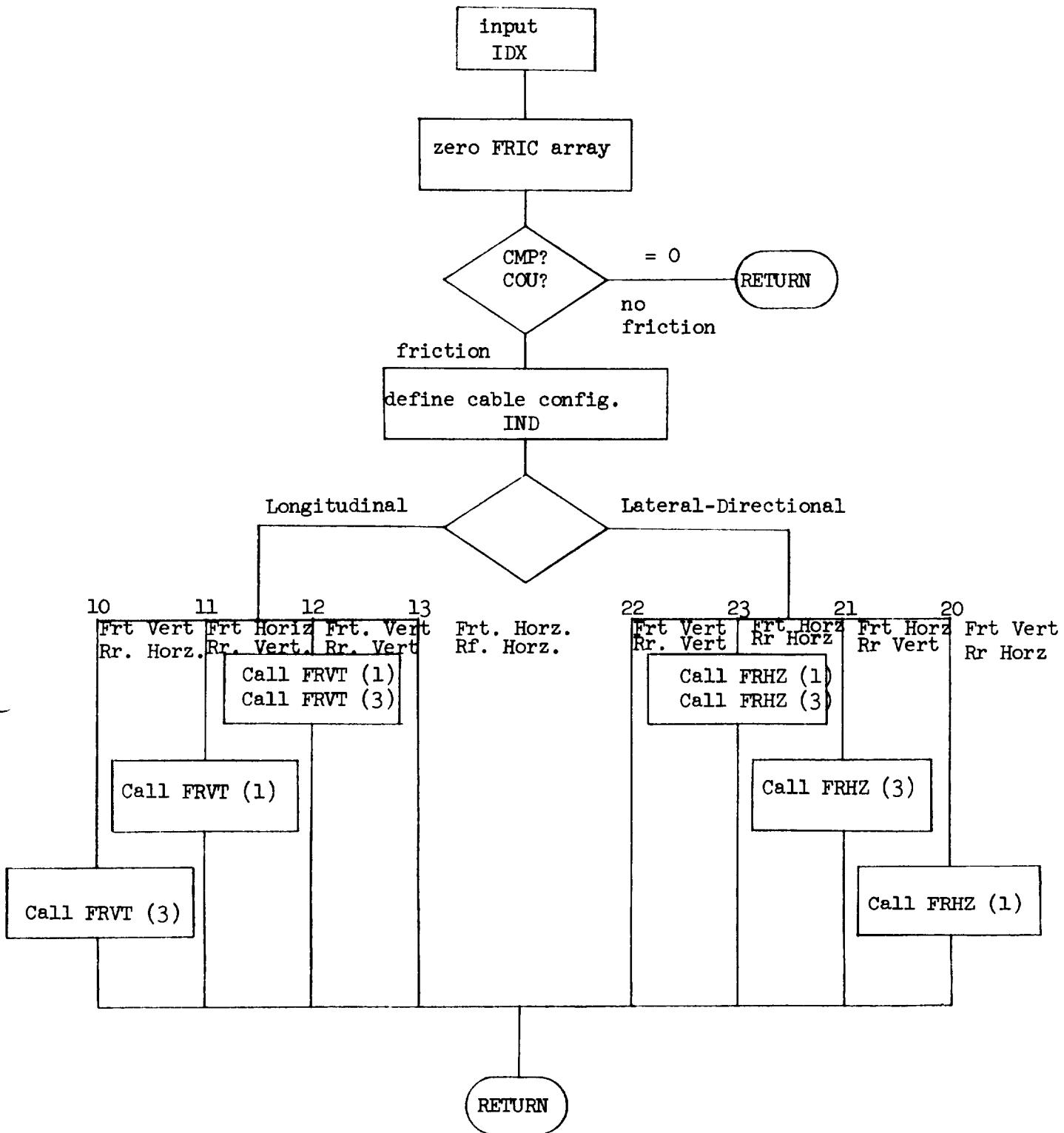


Figure 10.1 - FLOW DIAGRAM - SUBROUTINE FRIC

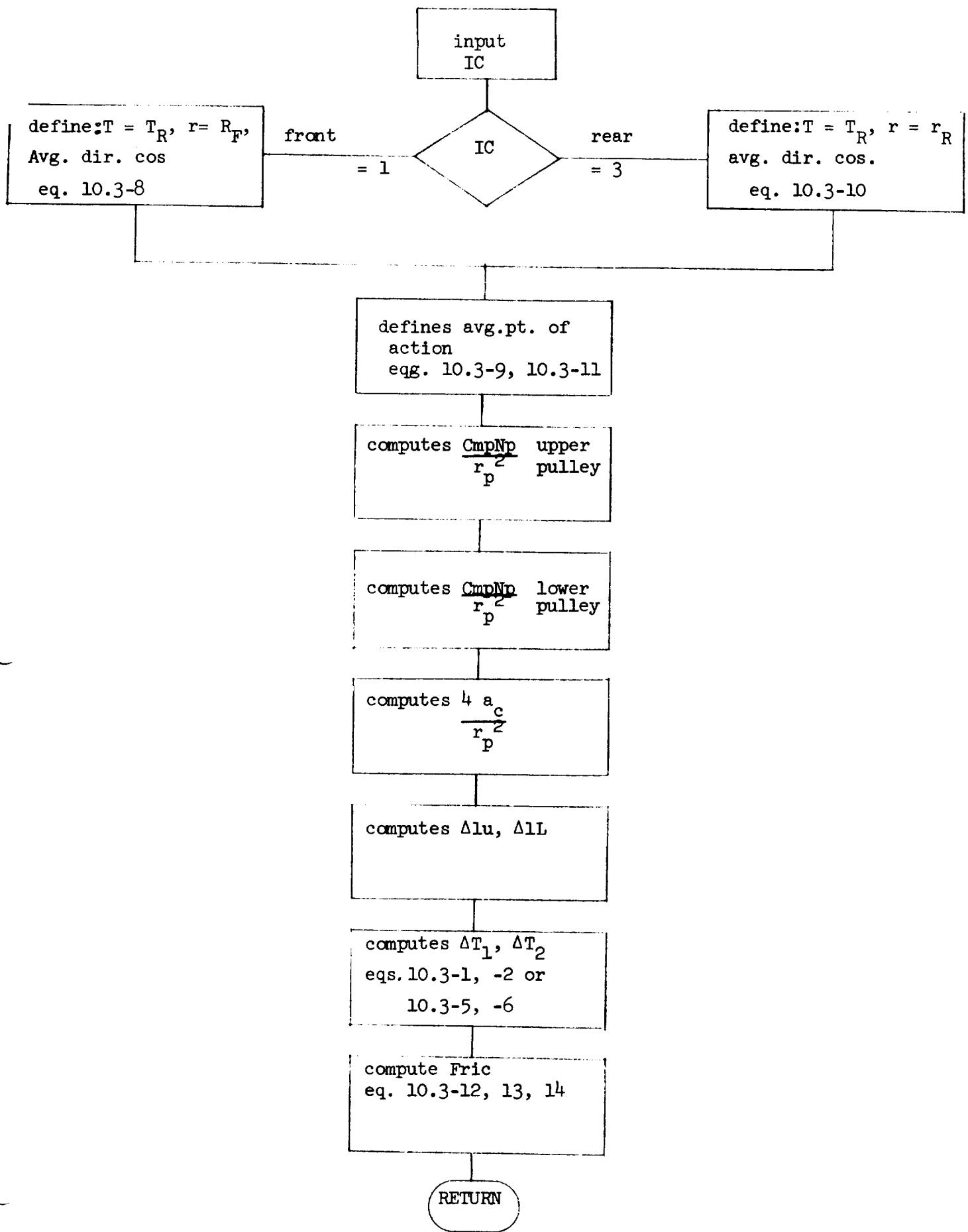


FIGURE 10.2 - FLOW CHART - SUBROUTINE FRVT

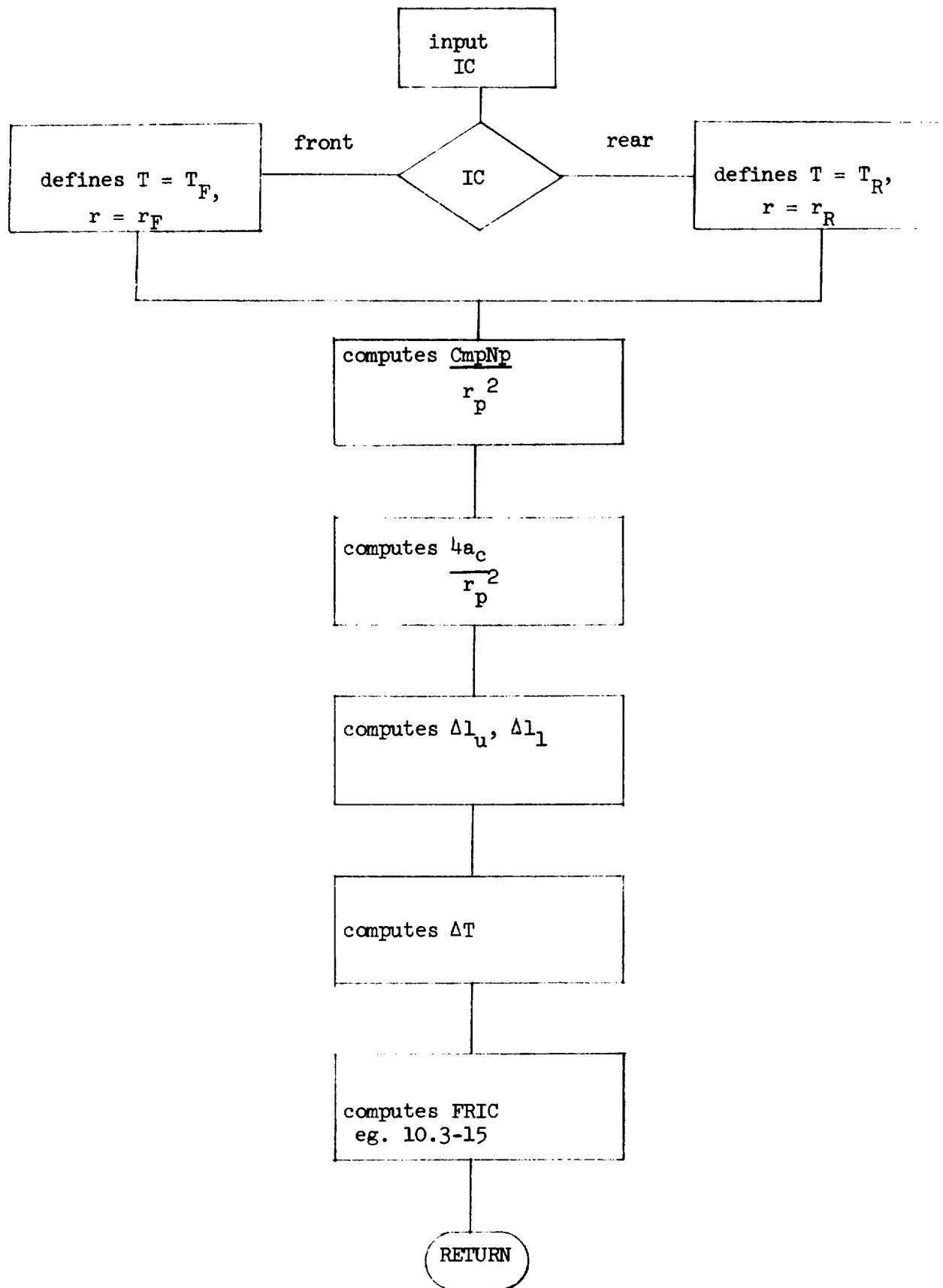


FIGURE 10.3 - FLOW DIAGRAM - SUBROUTINE FRHZ

11.0 INPUT DATA

The format for input data is most easily explained by reproducing the 'READ' statements as they appear in the program.

READ (IR, 1) (TITLE (I), I = 1, 20) (1)

1 FORMAT (20A4)

READ (IR, 2) (KODE(I), I = 1, 16) (2)

2 FORMAT (15I5)

Then either 3A or 3B: The value of KODE (7) will determine which input to use.

READ (IR, 3) (AERO (I), I = 1, 36) (3A)

CALL TABIN1 (1, 36) (See Appendix A) (3B)

Continuing:

READ (IR, 3) (AERO (I), I = 44, 59) (4)

READ (IR, 3) (AERO (I), I = 66, 130) (5)

3 FORMAT (6 E12.5)

If unsnubbed snubber data is to be read in (determined by KODE (12)) the following statement applies.

CALL TABIN (1, 2) (See Appendix A)

If unsnubbed data is not to be read in computations begin.

After completion of the first run the following 'READ' statements initialize another run.

READ (IR, 1) (TITLE (I), I = 1, 20) (6)

READ (IR, 2) (KODE (I), I = 1, 16) (7)

READ (IR, 3) I, VALUE

I = element in the 'AERO' array to be changed.

VALUE = new value of the element

NOTE: If I > 1 this 'READ' statement is repeated.
If I = 0 the program begins computation.
All succeeding cases follow the same format.

A description of the aforementioned arrays follows.

<u>ARRAY</u>	<u>DESCRIPTION</u>
TITLE	Alpha-numeric array containing title describing the run to be made.
KODE	Array containing various program option parameters.
AERO	Array containing all the input data pertaining to model, mount system and tunnel condi- tions.

11.1 KODE, AERO Description

A description of each element in the 'KODE' and 'AERO' array follows:

<u>NAME</u>	<u>VALUE</u>	<u>DESCRIPTION</u>
KODE (1)		Run number
KODE (2)	-1	Calculate longitudinal stability only
	0	Calculate lateral/directional stability only
	+1	Calculate both longitudinal and lateral/ directional stability
KODE (3)	0	No root locus
	+1	Do root locus
KODE (4)		Element in 'AERO' array to be varied for root locus
KODE (5)	0	Basic printout
	+1	Basic printout plus various test parameters
KODE (6)	+1	Front cable vertical - rear cable horizontal
	+2	Front cable horizontal - rear cable vertical
	+3	Front and rear cable vertical

NAME	VALUE	DESCRIPTION
	+4	Front and rear cable horizontal
KODE (7)	+1	Aero data to be input in table form
	0	Aero data to input at specific mach number
KODE (8)	+4	Longitudinal matrix with no stability augmentation
	+5	Longitudinal matrix with stability augmentation
KODE (9)	+3	Lateral/directional matrix, no stability augmentation
	+4	Lateral/directional matrix, with yaw stability augmentation
	+5	Lateral/directional matrix, with roll and yaw stability augmentation
KODE (10)	0	No snubber
	+1	Analyze snubber in unsnubbed condition
	+2	Analyze snubber in snubbed condition
KODE (11)	0	No anti-lift cable
	+1	Anti-lift cable in
KODE (12)	0	No unsnubbed snubber data input
	+1	Unsnubbed snubber data will be read in

	UNITS	LABEL	DESCRIPTION
AERO (1)	1/ft./sec.	CDU	$\partial C_D / \partial (u/V_\infty)$ $[C_{D_u}]$
AERO (2)	1/ft./sec.	CLU	$\partial C_D / \partial (u/V_\infty)$ $[C_{L_u}]$
AERO (3)	1/ft./sec.	CMU	$\partial C_m / \partial (u/V_\infty)$ $[C_{m_u}]$
AERO (4)	1/rad	CDA	$\partial C_D / \partial (\alpha)$ $[C_{D_\alpha}]$
AERO (5)	1/rad	CLA	$\partial C_L / \partial (\alpha)$ $[C_{L_\alpha}]$
AERO (6)	1/rad	CMA	$\partial C_m / \partial (\alpha)$ $[C_{m_\alpha}]$
AERO (7)	1/rad/sec	CDQ	$\partial C_D / \partial (\dot{q}C/2V_\infty)$ $[C_{D_q}]$
AERO (8)	1/rad/sec	CLQ	$\partial C_L / \partial (\dot{q}C/2V_\infty)$ $[C_{L_q}]$
AERO (9)	1/rad/sec	CMQ	$\partial C_m / \partial (\dot{q}C/2V_\infty)$ $[C_{m_q}]$
AERO (10)	N.D.	CDO	Drag coefficient at $\alpha = 0$ $[C_{D_0}]$
AERO (11)	N.D.	CLO	Lift coefficient at $\alpha = 0$ $[C_{L_0}]$
AERO (12)	N.D.	CMO	Pitching moment at $\alpha = 0$ $[C_{m_0}]$
AERO (13)	1/rad	CDDE	$\partial C_D / \partial (\delta_e)$ $[C_{D_{\delta_e}}]$
AERO (14)	1/rad	CLDE	$\partial C_D / \partial (\delta_e)$ $[C_{D_{\delta_e}}]$
AERO (15)	1/rad	CMDE	$\partial C_m / \partial (\delta_e)$ $[C_{m_{\delta_e}}]$
AERO (16)	1/rad/sec	CDAD	$\partial C_D / \partial (\dot{\alpha}C/2V_\infty)$ $[C_{D_\alpha}]$
AERO (17)	1/rad/sec	CLAD	$\partial C_D / \partial (\dot{\alpha}C/2V_\infty)$ $[C_{L_\alpha}]$
AERO (18)	1/rad/sec	CMAD	$\partial C_m / \partial (\dot{\alpha}C/2V_\infty)$ $[C_{m_\alpha}]$
AERO (19)	1/rad/sec	CYB	$\partial C_y / \partial (\theta)$ $[C_{y_\theta}]$
AERO (20)	1/rad	CLB	$\partial C_y / \partial (\theta)$ $[C_{y_\theta}]$
AERO (21)	1/rad	CNB	$\partial C_n / \partial (\theta)$ $[C_{n_\theta}]$
AERO (22)	1/rad/sec	CYP	$\partial C_y / \partial (pb/2V_\infty)$ $[C_{y_p}]$
AERO (23)	1/rad/sec	CLP	$\partial C_y / \partial (pb/2V_\infty)$ $[C_{e_p}]$
AERO (24)	1/rad/sec	CNP	$\partial C_n / \partial (pb/2V_\infty)$ $[C_{n_p}]$
AERO (25)	1/rad/sec	CYR	$\partial C_y / \partial (rb/2V_\infty)$ $[C_{y_r}]$
AERO (26)	1/rad/sec	CLR	$\partial C_e / \partial (rb/2V_\infty)$ $[C_{e_r}]$

	UNITS	LABEL	DESCRIPTION
AERO (27)	1/rad/sec	CNR	$\partial C_n / \partial (rb/2V_o)$ [C _{n_r}]
AERO (28)	1/rad	CYDR	$\partial C_y / \partial (\delta_r)$ [C _{y_r}]
AERO (29)	1/rad	CLDR	$\partial C_l / \partial (\delta_r)$ [C _{l_r}]
AERO (30)	1/rad	CNDR	$\partial C_n / \partial (\delta_r)$ [C _{n_r}]
AERO (31)	1/rad	CYDA	$\partial C_y / \partial (\delta_a)$ [C _{y_a}]
AERO (32)	1/rad	CLDA	$\partial C_l / \partial (\delta_a)$ [C _{l_a}]
AERO (33)	1/rad	CNDA	$\partial C_n / \partial (\delta_a)$ [C _{n_a}]
AERO (34)	1/rad	CYDS	$\partial C_y / \partial (\delta_s)$ [C _{y_s}]
AERO (35)	1/rad	CLDS	$\partial C_l / \partial (\delta_s)$ [C _{l_s}]
AERO (36)	1/rad	CNDS	$\partial C_n / \partial (\delta_s)$ [C _{n_s}]
AERO (44)	in.	XREF*	Distance from aerodynamic ref. center to the equation ref. center along the X body axis
AERO (45)	in.	ZREF	Distance from aerodynamic ref. center to the equation ref. center along the Z body axis
AERO (46)	in.	XCG	Distance from model mass & inertia ref. center to the equation ref. center along the X body axis
AERO (47)	in.	ZCG	Distance from model mass & inertia ref. center to the equation ref. center along the Z body axis
AERO (48)		AMACH	Tunnel mach number
AERO (49)	ft/sec	VO	Tunnel velocity
AERO (50)	slugs	AM	Model mass
AERO (51)	slug/ft ³	RHO	Tunnel density

	UNITS	LABEL	DESCRIPTION
AERO (52)	lbs	WT	Model weight
AERO (53)	ft	B	Model reference span
AERO (54)	ft	CBAR	Model reference chord
AERO (55)	ft ²	SW	Model reference wing area
AERO (56)	slug/ft ²	XIXZ	Model cross product of inertia (I_{XZ})
AERO (57)	slug/ft ²	XIXX	Model roll inertia (I_{xx}), body axis at C.G.
AERO (58)	slug/ft ²	YIYY	Model pitch inertia (I_{yy}), body axis at C.G.
AERO (59)	slug/ft ²	ZIZZ	Model yaw inertia (I_{zz}), body axis at C.G.
AERO (66)	in.	WLUF	Water line-upper front cable tie-down point (fr. vert.)
AERO (67)	in.	WLLF	Water line-lower front cable tie-down point (ft. vert.)
AERO (68)	in.	WLUR	Water line-upper rear cable tie-down point (rr. vert.)
AERO (69)	in.	WLLR	Water line-lower rear cable tie-down point (rr. vert.)
AERO (70)	in.	WLHF	Water line-horizontal front cable tie-down point (ft. hor.)
AERO (71)	in.	WLHR	Water line-horizontal rear cable tie-down point (rr. hor.)
AERO (72)	in.	STAF	Station-front cable tie-down point (fr. vert. or hor.)
AERO (73)	in	STAR	Station-rear cable tie-down point (rr. vert. or hor.)
AERO (74)	in	BLHF	Butt line-horizontal front cable tie-down point (fr. hor.)

	UNITS	LABEL	DESCRIPTION
AERO (75)	in.	BLHR	Butt line-horizontal rear cable tie-down point (rr. hor.)
AERO (76)	in.	WLCR	Water line-equation reference point
AERO (77)	in.	STACR	Station - equation reference point
AERO (78)	in.	BLCR	Butt line-equation reference point
AERO (79)	in.	EF**	Distance along X body axis from ref. center to vertical front pulley
AERO (80)	in.	ER	Distance along X body axis from ref. center to vertical rear pulley
AERO (81)	in.	AF	Distance along X body axis from ref. center to horizontal front pulley
AERO (82)	in.	AR	Distance along X body axis from ref. center to horizontal rear pulley
AERO (83)	in.	HUCF	Distance along Z body axis from ref. center to upper front pulley
AERO (84)	in.	HLCF	Distance along Z body axis from ref. center to lower front pulley
AERO (85)	in.	HUCR	Distance along Z body axis from ref. center to upper rear pulley
AERO (86)	in.	HLCR	Distance along Z body axis from ref. center to lower rear pulley
AERO (87)	in.	DCF	Distance along Y body axis from ref. center to horizontal front pulley
AERO (88)	in.	DCR	Distance along Y body axis from ref. center to horizontal rear pulley

	UNITS	LABEL	DESCRIPTION
AERO (89)		blank	
AERO (90)	in	RVF	Radius of vertical front pulley
AERO (91)	in	RHF	Radius of horizontal front pulley
AERO (92)	in	RVR	Radius of vertical rear pulley
AERO (93)	in	RHR	Radius of horizontal rear pulley
AERO (94)	lbs	TRO	Rear cable tension
AERO (95)	lbs/in	AKR	Rear cable spring constant
AERO (96)	ft-#/rad	COU	Pulley Coulomb friction (a_c)
AERO (97)	in	STLTT	Station - lift cable tie-down point
AERO (98)	in	WLLTT	Water line - lift cable tie-down point
AERO (99)	lbs	TLFTO	Lift cable tension
AERO (100)	lbs/in	AKLFT	Lift cable spring constant
AERO (101)		blank	
AERO (102)	in	ALTX*	Distance along X body axis from lift cable attachment point to the equation reference center
AERO (103)	in	ALTZ	Distance along Z body axis from lift cable attachment point to the equation reference center
AERO (104)	ft-#/RPS	CMP	Pulley rolling friction coefficient
AERO (105)	in	SNUX***	Distance along X body axis from model upper attachment point to the equation reference center
AERO (106)	in	SNUY	Distance along Y body axis from model upper snubber attachment point to the equation reference center
AERO (107)	in	SNUZ	Distance along Z body axis from model upper snubber attachment point to the equation reference center

	UNITS	LABEL	DESCRIPTION
AERO (108)	in	SNLX	Distance along X body axis from model lower snubber attachment point to the equation reference center
AERO (109)	in	SNLY	Distance along Y body axis from model lower snubber attachment point to the equation reference center
AERO (110)	in	SNLZ	Distance along Z body axis from model lower snubber attachment point to the equation reference center
AERO (111)	in	SNUST	Station - upper snubber tie-down point
AERO (112)	in	SNUWL	Water line - upper snubber tie-down point
AERO (113)	in	SNUBL	Butt line - upper snubber tie-down point
AERO (114)	in	SNLST	Station - lower snubber tie-down point
AERO (115)	in	SNLWL	Water line - lower snubber tie-down point
AERO (116)	in	SNLBL	Butt line - lower snubber tie-down point
AERO (117)	lbs	TUSNO	Upper snubber, snubbed tension
AERO (118)	lbs	TLSNO	Lower snubber, snubbed tension
AERO (119)	lbs/in	AKSNU	Upper snubber, snubbed spring constant
AERO (120)	lbs/in	AKSNL	Lower snubber, snubbed spring constant
AERO (121)	lbs/in/sec	ADSNU	Upper snubber, snubbed damping constant

	UNITS	LABEL	DESCRIPTION
AERO (122)	lbs/in/sec	ADSNL	Lower snubber, snubbed damping constant
AERO (123)	rad/rad/sec	AKSY	Feedback gain - yaw rate to rudder
AERO (124)	rad/rad/sec	AKPHI	Feedback gain - roll rate to aileron
AERO (125)	rad/rad/sec	AKTHE	Feedback gain - pitch rate to elevator
AERO (126)	blank		
AERO (127)	sec.	T1SY	Time constant for lag on yaw rate feedback
AERO (128)	sec.	T2PHI	Time constant for lag on roll rate feedback
AERO (129)	sec.	T3THE	Time constant for lag on pitch rate feedback
AERO (130)	blank		

* See Figure 11.1 for pictorial representation of various reference centers

** See Figure 11.2 for pictorial representation of pulley geometry

*** See Figure 11.3 for pictorial representation of snubber cable geometry

11.2 TABLE INPUT

If the aero data and snubber data are to be read in table format, the following discussion applies.

The first 36 tables contain the aero derivatives in stability axis vs. mach number. The order is the same as AERO (1) through AERO (36). The units for each derivative are also the same as AERO (1) through AERO (36). The table input format is shown in Appendix A. This data is read in under TABIN1.

The unsnubbed snubber data is contained in Tables 1 and 2. Table 1 contains cable tension (lbs) vs. dynamic pressure (psf) and linear distance (in) between model tie-down point and tunnel side wall. Table 2 contains cable angle (rad) vs. dynamic pressure (psf) and linear distance (in) between model tie-down point and tunnel side wall. The tensions and angles mentioned here are described in detail in section 8.0. The table input format is shown in Appendix A. This data is read in under TABIN.

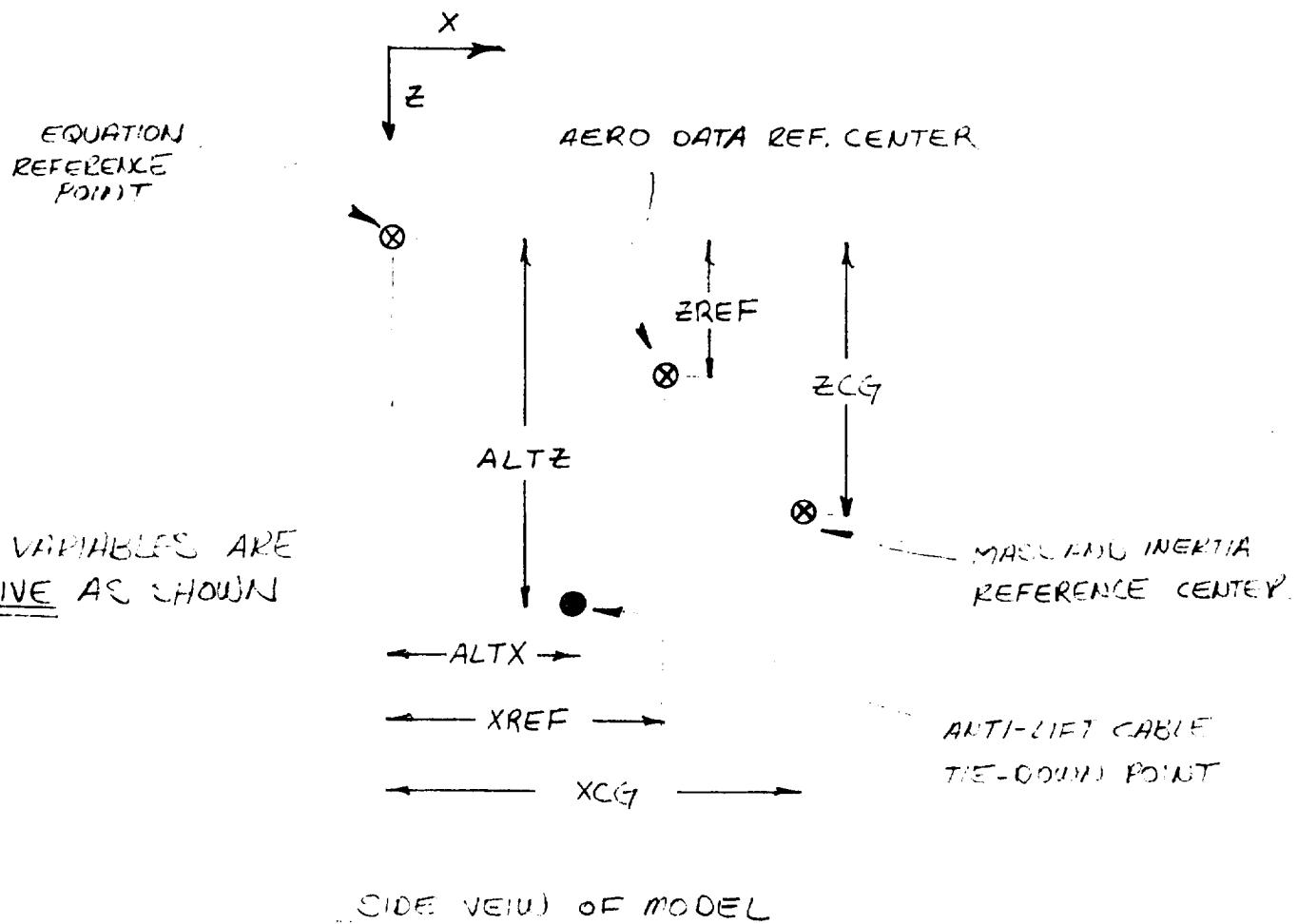
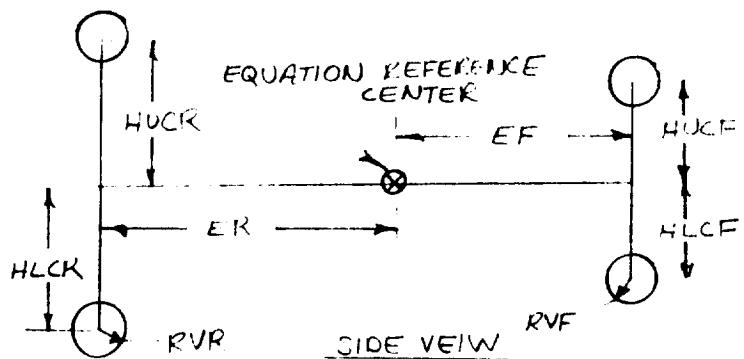
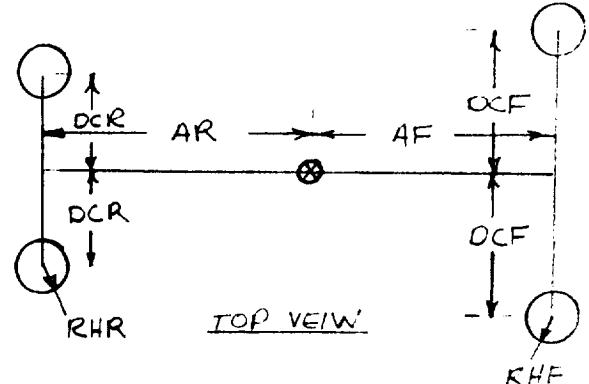
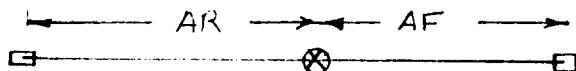


FIG. II.1 - REFERENCE CENTER AND LIFT CABLE INPUT DATA.

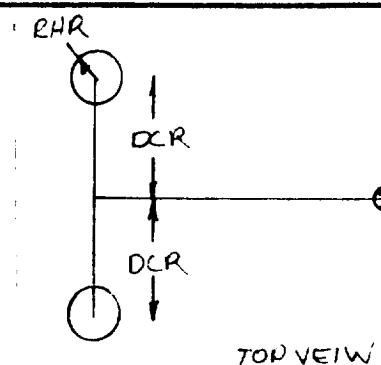
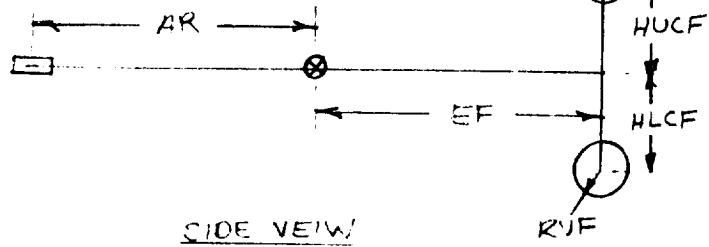


TOP VIEW.

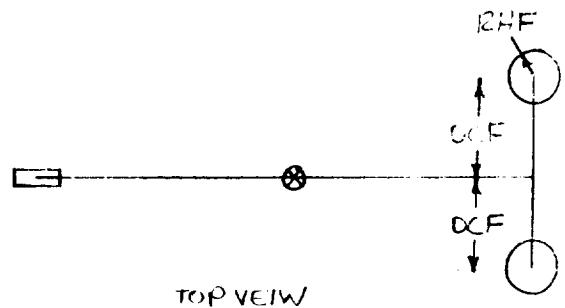
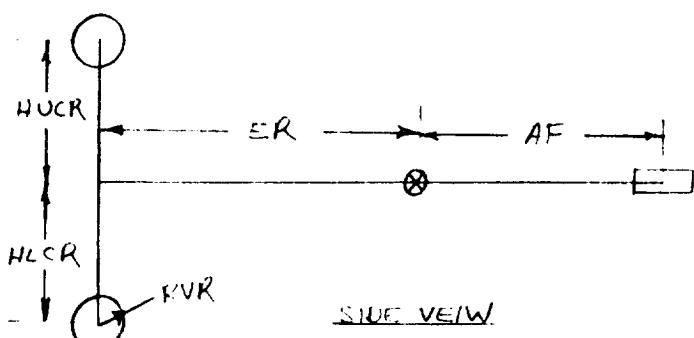
FRONT VERTICAL - REAR VERTICAL



FRONT HORIZONTAL - REAR HORIZONTAL

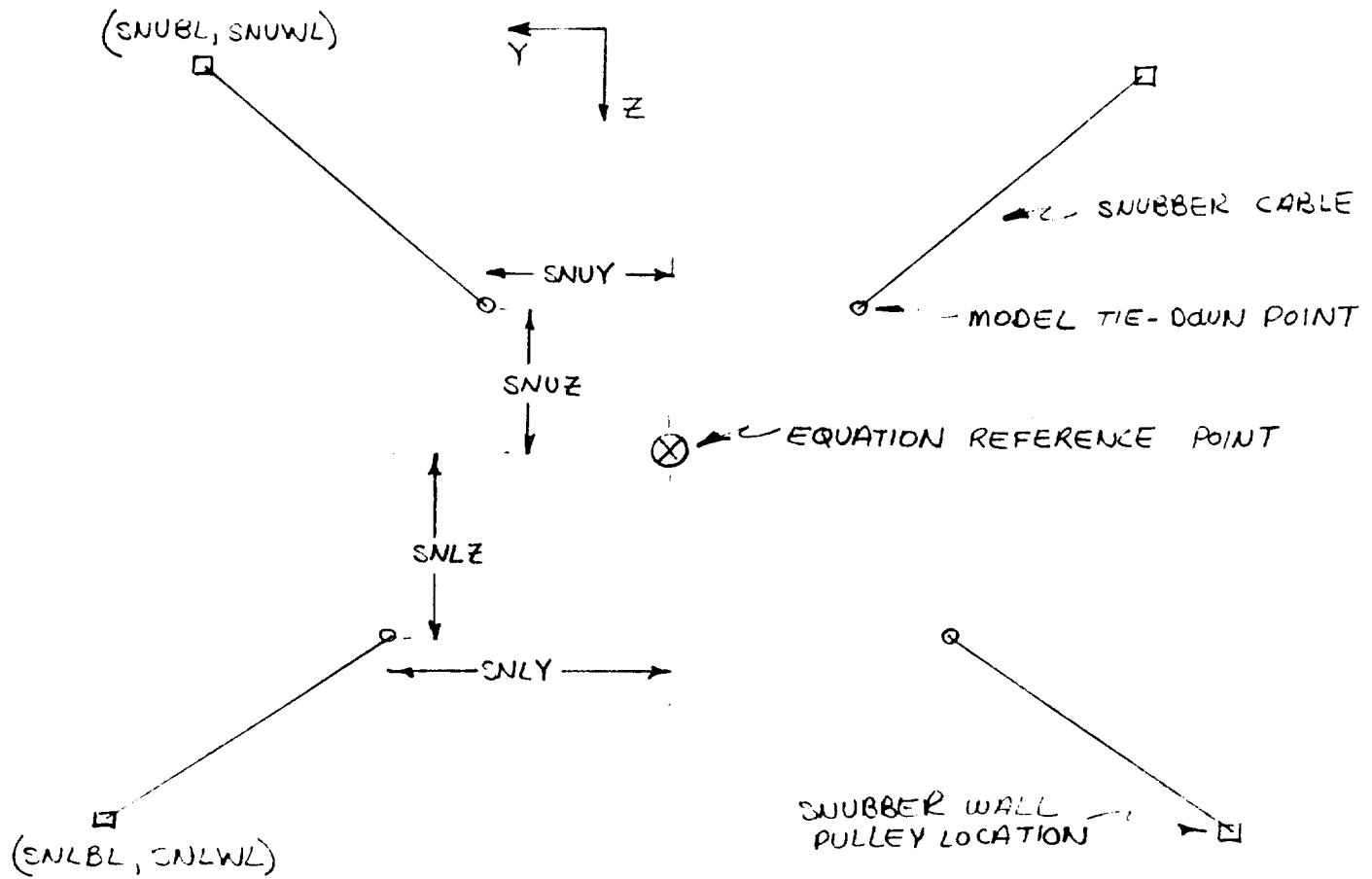


FRONT VERTICAL - REAR HORIZONTAL



FRONT HORIZONTAL - REAR VERTICAL

FIG. 1.2 - PULLEY GEOMETRY



MODEL - FRONT VIEW

NOTE: ALL DISTANCES
ARE POSITIVE AS SHOWN

MODEL - SIDE VIEW

FIG. 11.2. - SNUBBER CABLE ARRANGEMENT

REFERENCES

- 1) Reed, Abbott - A New 'Free Flight' Mount System For High Speed Wind Tunnel Flutter Models - NASA - Langley Research Center - 9/63
- 2) Bennett - Comments on Mount System Damping Based on Pulley Rolling Friction
- 3) Thelander Aircraft Motion Analysis - FOL-TOR-64-70
- 4) Methods of Analysis and Synthesis of Piloted Aircraft Flight Control Systems - BU AER Report AE-61-41-3/52
- 5) Dynamics of the Airframe - BU AER Report AE-61-42-9/52
- 6) Hildebrand - Advanced Calculus for Engineers

APPENDIX A

A-1

TABIN, TABIN1

If data is to be input in table form, subroutine TABIN is used. When reading aero data the first independent variable is mach number. When reading unsnubbed snubber data the first independent variable is dynamic pressure (psf) and the second independent variable is length (L_s) in inches.

Restrictions:

1. The tabular values for the independent variables must be in algebraically increasing order.
2. The independent variables and functional values of the table must:
 - a) Be single precision numbers less than 99999E9.
 - b) Have a maximum of 7 significant figures if positive.
 - c) Have a maximum of 6 significant figures if negative.

A maximum of 99 cards is allowed for each table.

Usage:

A. Tables are prepared according to the form on the following page. Variable noted there are:

K = table number - any positive fixed point number.

L1 = Number of tabular values of the first independent variable (x).

L2 = Number of tabular values of the second independent variable (y).

Seq. no. = sequence number of card within a table beginning with 0 for the first card, 1 for the second, etc.

Z = Value of the third independent variable (z).
A separate table is needed for each tabular value of Z.

F(i,j) = functional value for x_i , y_j , and Z.

The last card for every set of tables read in MUST BE BLANK.

CARD FORMAT FOR EACH TABLE

	K	L1	L2							Seq. No.
Column	9-12	13-14	15-16							71-72

Z	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	Seq. No.
---	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------------

For first 9 x-values

y_1	$f(1,1)$	$f(2,1)$	$f(3,1)$	$f(4,1)$	$f(5,1)$	$f(6,1)$	$f(7,1)$	$f(8,1)$	$f(9,1)$	Seq. No.
-------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------

⋮

y_{L2}	$f(1, L2)$	$f(2, L2)$	$f(3, L2)$	$f(4, L2)$	$f(5, L2)$	$f(6, L2)$	$f(7, L2)$	$f(8, L2)$	$f(9, L2)$	Seq. No.
----------	------------	------------	------------	------------	------------	------------	------------	------------	------------	-------------

For second 9 x-values

y	$f(10, 1)$	$f(11, 1)$	$f(12, 1)$	$f(13, 1)$	$f(14, 1)$	$f(15, 1)$	$f(16, 1)$	$f(17, 1)$	$f(18, 1)$	Seq. No.
---	------------	------------	------------	------------	------------	------------	------------	------------	------------	-------------

⋮

y_{L2}	$f(10, L2)$	$f(11, L2)$	$f(13, L2)$	$f(13, L2)$	$f(14, L2)$	$f(15, L2)$	$f(16, L2)$	$f(17, L2)$	$f(18, L2)$	Seq. No.
----------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------	-------------

Col. 1-7 8-14 15-21 22-28 29-35 36-42 43-49 50-56 57-63 64-70 71-72

Additional x values are similarly handled.

BLANK CARD - last in set of data read in at one time.

B. Calling sequence:

CALL TABIN (NUMTBL, IZ, NG)

NUMTBL = Number of the first table to be read in.
= 1 for the first set of tables read in
on a job.

IZ = Maximum number of tables in storage at
one time.

NG = error return - set equal to:

0 - tables are read in successfully
1 - error in loading tables.

C. COMMON statement to be made in the calling program:

COMMON ZZZ(n)

where ZZZ is a dummy name, n is computed as follows:

$$n = 3IZ + \sum_{i=1}^{IZ} (Ll_i + 1) (L2_i + 1)$$

ZZZ must be the first array stored in blank COMMON.

A-2 STINT, STINT1

Subroutine STINT is a linear interpolation routine used to
gather data from the tables.

Purpose: To look up in a table and interpolate functions of
1, 2, or 3 variables.

Restrictions: 1. CALL TABIN to read in tables (see TABIN write-up).
2. Extrapolation is not performed for arguments off
the tables.

Method:*

$x = ARG1$	$x_o < x < x_1$	x_o, x_1 - consecutive tabular values
$y = ARG2$	$y_o < y < y_1$	y_o, y_1 - consecutive tabular values
$z = ARG3$	$z_o < z < z_1$	z_o, z_1 - tabular values for consecutive tables
$f(i,j)$	functional value at (x_i, y_j)	

$$A = \frac{(y_1 - y) \left[(x_1 - x) f(0,0) - (x_0 - x) f(1,0) \right]}{(y_1 - y_0) (x_1 - x_0)}$$

$$- \frac{(y_0 - y) \left[(x_1 - x) f(0,1) - (x_0 - x) f(1,1) \right]}{(y_1 - y_0) (x_1 - x_0)}$$

Single table interpolation

$$FCT = f(1,0) - \frac{x_1 - x}{x_1 - x_0} (f(1,0) - f(0,0))$$

Double table interpolation

FCT = A

Triple table interpolation

A is found for the z_o table (A_o) and the z_1 table (A_1).

$$FCT = A_1 - \frac{z_1 - z}{z_1 - z_o} (A_1 - A_o)$$

Usage: CALL STINT (ARG1, ARG2, ARG3, MINTBL, MAXTBL, FCT, NG)

ARG1 = floating point value used as search argument 1

ARG2 = floating point value used as search argument 2

ARG3 = floating point value used as search argument 3

MINTBL = lower bound of table position number.

MAXTBL = upper bound of table position number.

FCT = floating point variable which is returned with the result of the interpolation.

NG = Error indicator

= 1 - error in loading tables (set by TABIN)

= 2 - error in calling sequence or machine error

= 3 - argument not in domain of table

= 4 - argument(s) are within tables but function is discontinuous or non-existent.

If there is no error, the last value of NG remains in storage. NG should be interrogated after each return from STINT. If NG \neq 0, set NG to 0 after taking appropriate error control action and before calling STINT again.

For single table interpolation set ARG2 = 0, and ARG3 = 0

For double table interpolation set ARG3 = 0.

For triple table interpolation

Normally at least 2 tables are needed. The tables must have consecutive position numbers. If ARG3 is exactly equal to the tabular value of z (third independent variable), only one table is needed.

A-3 MASH

Subroutine MASH is used to reduce large matrices to smaller ones. It only reduces terms of the same order.

A-4 MATRIX, PRBML, PQFBL

Subroutines MATRIX, PRBML, and PQFBL are used to obtain the eigenvalues of the polynomial matrices defined in subroutines LONG and LAT. Subroutine MATRIX takes the polynomial matrix and derives the characteristic polynomial for that matrix. The roots of the characteristic polynomial are then established in subroutines PRBML and PQFBL. PRBML and PQFBL are called from MATRIX. The dimension statements for this routine are presently set up for a 7 x 7 matrix. If in the future this is to be changed the following definitions will be necessary.

Call MATRIX (A, N, ROOTS, K4A, IER)

A: Input matrix, Dimension = (N, N, 3) the first index refers to the row, second to the column, and third to the polynomial coefficient with A (i, j, 1) = constant term, A(i, j, z) = linear term, etc.

N: The actual size of the input matrix.

ROOTS: A complex array. Dimension = 29
K4A: Equals the number of roots generated.
IER: Contains error code message. See listing
of PQFB1 and PRBML for description.

The routine is limited to second order polynomials. That is, each polynomials represented in the A array can be no greater than second order.

APPENDIX B

A sample listing of input data is included as an example. The set of input cards listed below is the set provided with the accompanying deck.

Referring to the listing, Case 1 is one in which a root locus is done with the rear cable tension being the parameter varied. Both longitudinal and lateral stability calculations are made. The cable configuration is front vertical rear horizontal with no snubber effects. Case 2 is the same variation in rear cable tension with the unsnubbed snubber effects included. Case 3 is one in which the values for $C_{L\alpha}$ and $C_{m\alpha}$ are changed and only longitudinal stability effects are calculated. In Case 4, $C_{L\alpha}$ and $C_{m\alpha}$ are put back to their original values and the front pulleys are changed to the horizontal configuration. The output corresponding to this input data is contained in APPENDIX C.

FILEO CABLE DATA PI

GRUMMAN DATA SYSTEM

TEST DATA LRC

-1	1	1	94	0	1	0	4	3	0	0	1	
0.				0.		0.	0.		6.26			- .91
0.					-8.		.018		.105			.035
0.			.96		-1.5		0.		0.			0.
= .73			= .035		= .111		0.		= .19			- .01
0.			.050		- .092							
4.35			.00039		140.		9.16		1.4			430.
- .11			1.8		14.		14.					11.5
59.			-59.									
10.			285.				80.					175.
			26.4									8.4
8.4												
.88												
			177.		- .96							
-2.			3.		.05		2.		3.			2.
2.			3.		2.		180.		96.			72.
180.			-96.		72.		80.		80.			50.
30.			0.		0.							
0												

1 4 3

0	0	20.	100.	200.								1
0	0	20.	60.	80.								2
00.	0	25.	65.	85.								3
50.	0	30.	70.	90.								4

2 4 3

0	0	30.	100.	200.								1
0	1.57	1.20	1.00	.60								2
100.	1.57	1.10	.90	.40								3
200.	1.57	1.00	.80	.20								4

BLANK CARD

TEST DATA UNSNURRED SNUBBER

2 1 1 94 0 1 0 4 3 1 0 0

BLANK CARD

TEST DATA CHANGE CL AND CM ALPHA

3 -1 0 0 0 1 0 4 3 0 0 0

5 -5.5

6 -1.3

BLANK CARD

TEST DATA FRONT PULLEY HORIZONTAL

4 1 0 0 0 4 0 4 3 0 0 0

5 6.2

6 -.8

70 0

74 80.

81 26.4

87 8.4

91 .88

BLANK CARD

APPENDIX C

Contained in this Appendix is the program output
corresponding to the input list shown in Appendix B.

CASE NO=

TEST DATA FOR
PEAK CABLE VERTICAL, BIAS CABLE HORIZONTAL
NO SNUBBERS

BC LIFT/ANTI-LIFT CABLE

INPUT DATA AS SPECIFIED IN AERC ARRAY

AERO(1) = 0.0	AFFC(2) = 0.0	AERO(3) = 0.0	AERO(4) = 0.0	AERO(5) = 6.26
AERO(6) = -C.610	AERO(7) = C.C	AERC(8) = 0.0	AERC(9) = -A.00	AERO(10) = 0.180E-01
AERO(11) = C.105	AFFC(12) = 0.35CE-01	AERC(13) = 0.0	AERO(14) = 0.960	AERO(15) = -1.50
AERO(16) = 0.0	AFFC(17) = 0.0	AERO(18) = 0.0	AERO(19) = -0.730	AERC(20) = -0.350E-01
AERO(21) = C.111	AERO(22) = C.C	AERC(23) = -0.190	AERO(24) = -0.100E-01	AERO(25) = 0.0
AERO(26) = 0.500E-01	AFFC(27) = -0.920E-01	AERO(28) = 0.0	AERO(29) = 0.0	AERO(30) = C.C
AERC(31) = C.0	AERO(32) = 0.0	AERO(33) = 0.0	AERO(34) = 0.0	AERC(35) = 0.0
AERC(36) = C.0	AERO(37) = C.C	AERC(38) = 0.0	AERC(39) = 0.0	AERO(40) = 0.0
AERC(41) = C.C	AFFC(42) = 0.0	AERO(43) = 0.0	AERO(44) = 0.0	AERO(45) = C.C
AERO(46) = C.0	AERO(47) = 0.0	AERO(48) = 0.E90	AERO(49) = 430.	AERC(50) = 4.35
AERO(51) = C.39CE-C3	AERO(52) = 140.	AERC(53) = 9.16	AERO(54) = 1.40	AERO(55) = 11.5
AERC(56) = -0.110	AERO(57) = 1.80	AERO(58) = 14.0	AERO(59) = 14.0	AERC(60) = C.0
AERO(61) = C.0	AERO(62) = C.C	AERC(63) = 0.C	AERC(64) = 0.0	AERO(65) = 0.0
AERC(66) = 59. C	AFFC(67) = -59. C	AERC(68) = 0.0	AERC(69) = 0.0	AERO(70) = C.0
AERO(71) = 0.0	AFFC(72) = 10.0	AERO(73) = 285.	AERO(74) = 0.0	AERC(75) = 80.0
AERO(76) = C.0	AERO(77) = 175.	AERC(78) = 0.0	AERC(79) = 26.4	AERO(80) = 0.0
AERC(81) = C.0	AFFC(82) = 8.00	AERO(83) = 8.40	AERO(84) = 8.40	AERO(85) = 0.C
AERO(86) = 0.0	AERO(87) = 0.0	AERO(88) = 0.920	AERO(89) = 0.0	AERC(90) = 0.880
AERO(91) = C.0	AERO(92) = C.C	AERC(93) = 0.980	AERO(94) = 140.	AEO(95) = 3.00
AERO(96) = C.0	AFFC(97) = 177.	AERO(98) = -0.960	AERC(99) = 0.0	AEO(100) = 0.C
AERO(101) = 0.0	AERC(102) = -2.00	AERO(103) = 3.00	AERO(104) = 0.500E-01	AERO(105) = 2.00
AERO(106) = 3.0C	AERO(107) = 2.0C	AERC(108) = 2.00	AERO(109) = 3.00	AERO(110) = 2.00
AERO(111) = 189.	AFFC(112) = 96.0	AERO(113) = 72.C	AERO(114) = 180.	AERC(115) = -96.C
AERO(116) = 72.0	AERO(117) = 80.0	AERO(118) = 8C.C	AERO(119) = 5C.0	AERO(120) = 50.0
AERO(121) = 5.CC	AERO(122) = 5.0C	AERC(123) = 0.0	AERC(124) = 0.0	AERO(125) = 0.0
AERO(126) = 0.0	AFFC(127) = 0.0	AERO(128) = 0.0	AERO(129) = 0.0	AERO(130) = C.C

>>>> ROCT LOCUS VARYING AERO(94)

AERC(94) = 84.000

EE. ATT., DEPLIN, & CABLE TENSION

THETA = 2.20 DEG

DELTA = -0.15 EFC

PFT CAF. TENSICK = 0.760171E 02 IES

BR CAF. TENSION = C.84C1CE C2 IBS

>>> INCLINED STABILITY <<<

REAL IMAGINARY T H/D-SEC

PERIOD-SEC

DNATF-CPS

UNDNAT-CPs

DAMP RATIO

DECAY RATIO

-6.113E-01 +-4.524E 00 1.6862E 00 5.9306E-01 1.3893E 00 7.1976E-01 7.2273E-01 9.0527E-C2 8.2351E-01 5.6088E-01

-7.615E-01 +-7.3066E 00 9.0775E-01 1.1016E 00 8.5554E-01 1.1629E 00 1.1692E 00 1.0394E-01 9.4731E-01 5.1859E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY T E/C-SEC

PERIOD-SEC

DNATF-CPS

UNDNAT-CPs

DAMP RATIO

DECAY RATIO

-8.0267E-01 +-3.222E CC 1.1580E CO 1.9508E CO 5.1262E-01 5.2830E-01 2.4181E-01 2.2599E 00 2.0891E-01

-1.9427E CC +-4.C231E CC 3.4764E-01 2.8749E 00 1.5618E 00 6.4029E-01 7.1053E-01 4.4386E-01 4.4930E 00 4.4501E-02

-3.9775E-01 +-8.1582E 00 1.7427E 00 7.737E-C1 7.7017E-01 1.2998E 00 1.3000E 00 4.8657E-C2 4.4745E-01 7.3614E-01

AERC(94) = 98.000

EE. ATT., DEPLIN, & CABLE TENSION

THETA = 2.22 DEG

DELTA = -0.5C DEG

PFT CAF. TENSICK = 0.9568992E 01 IES

BR CAF. TENSION = C.957371CE C2 IBS

>>> INCLINED STABILITY <<<

REAL IMAGINARY T H/D-SEC

PERIOD-SEC

DNATF-CPS

UNDNAT-CPs

DAMP RATIO

DECAY RATIO

-6.6201E-01 +-0.7155E CO 6.6654E-01 1.3256E 00 7.5038E-01 7.5796E-01 9.7174E-02 8.8356E-01 5.6203E-C1

-7.1231E-01 +-7.6113E 00 9.7310E-01 1.0276E 00 8.2551E-C1 1.2114E 00 1.2167E 00 9.3179E-C2 8.4632E-01 5.5543E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY T E/C-SEC

PERIOD-SEC

DNATF-CPS

UNDNAT-CPs

DAMP RATIO

DECAY RATIO

-9.1741E-01 +-3.2566E CO 1.5555E-01 1.9294E 00 5.1830E-01 5.3847E-01 2.7116E-C1 2.5536E 00 1.7033E-C1

-1.8645E CC +-4.5973E 00 3.7176E-01 2.6899E 00 1.3666E 00 7.3168E-01 7.8956E-01 3.7584E-01 3.6764E 0C 7.5218E-02

-6.1133E-01 +-8.4915E CC 1.6851E 00 5.9342E-C1 7.3953E-01 1.3515E 00 1.3533E 00 4.8384E-02 4.3909E-01 7.376CE-C1

AERC(94) = 112.00

EE. ATT., DEPLIN, & CABLE TENSION

THETA = 2.24 DEG

DELTA = -0.61 DEG

PFT CAF. TENSICK = C.97371CE C2 IBS

BR CAF. TENSION = 0.112C31E C3 IFS

>>> INCLINED STABILITY <<<

REAL IMAGINARY T H/D-SEC

PERIOD-SEC

DNATF-CPS

UNDNAT-CPs

DAMP RATIO

DECAY RATIO

-5.0694E-01 +-4.9267E 00 1.3673E 00 1.2753E-01 1.2753E 00 7.8471E-01 7.8825E-01 1.0276E-C1 9.3272E-01 5.2387E-01

-6.6702E-01 +-7.9186E 00 1.0392E 00 9.6230E-01 7.9347E-01 1.2603E 00 1.2641E 00 8.3938E-02 7.6355E-01 5.5904E-C1

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY T E/C-SEC

PERIOD-SEC

DNATF-CPS

UNDNAT-CPs

DAMP RATIO

DECAY RATIO

-9.588E-01 +-3.3C21E CC 7.2263E-01 1.3833E 00 1.9028E 00 5.2555E-01 5.4726E-01 2.7884E-01 2.6320E 00 1.6132E-01

-1.8107E CC +-5.1177E CC 3.8261E-C1 2.6123E 00 1.2277E 00 8.1450E-01 3.3355E-01 3.2072E 00 1.0828E-01

-4.2385E-01 +-8.8130E 00 1.6354E 00 6.1148E-01 7.1295E-01 1.4026E 00 1.4043E 00 4.8035E-01 7.3925E-01

AERC(94) = 126.00

EE. ATT., DEPLIN, & CABLE TENSION

THETA = 2.26 DEG

DELTA = -0.71 DEG

PFT CAF. TENSICK = 0.139046E 03 IES

EE CABLE TENSION = 0.126631E 03 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-5.4556E-01 +-0.5022E 00 1.2702E CC

-6.2426E-01 +-0.2248E 00 1.1031E 00

>>> LATERAL/DIRECTORIAL STABILITY <<<

REAL IMAGINARY T E/T-SEC

-5.7134E-01 +-1.3689E 00 7.1201E-01

-1.7801E 00 2.5704E 00

-4.3553E-01 +-9.1233E 00 1.5915E 00

AERFC(94) = 149.90

EE. ATT., DEPICTING CABLE TENSION

TEETA = 2.0 DEG

DELTA = -0.95 DEG

EFT CAF. TENSION = 0.12672CE 03 IBS

BR CAF. TENSION = 0.140032E 03 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T E/T-SEC

-5.7231E-01 +-1.2749E 00 6.3043E-01

-5.9482E-01 +-0.5275E 00 1.1653E 00

>>> LATERAL/DIRECTORIAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-5.7845E-01 +-1.4693E 00 7.0841E-01

-1.7685E 00 3.9193E-01

-4.4653E-01 +-5.4233E 00 1.5523E CC

AERFC(94) = 154.00

EE. ATT., DEFLINING CABLE TENSION

THEIA = 2.30 DEG

DELTA = -2.5E DEG

PFT CAF. TENSION = 0.132393E 03 IBS

BR CAF. TENSION = 0.154333E 03 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-6.6662E-01 +-0.1666E 00 1.1435E 00

-5.6662E-01 +-0.8262E 00 1.2233E 00

>>> LATERAL/DIRECTORIAL STABILITY <<<

REAL IMAGINARY T E/T-SEC

-9.7944E-01 +-3.5346E 00 7.0770E-01

-1.7572E 00 +-6.3882E 00 3.5467E-01

-4.5659E-01 +-9.7155E 00 1.5168E 00

AERFC(94) = 168.00

EE. ATT., DEFLINING CABLE TENSION

TEETA = 2.1 DEG

DELTA = -1.11 DEG

EFT CAF. TENSION = 0.144667E 03 IBS

BR CAF. TENSION = 0.160034E 03 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T E/T-SIC

-6.297CE-01 +-0.4527E 00 1.1CE CC

-5.4266E-01 +-0.115CE 00 1.2773E CC

>>> LATERAL/DIRECTORIAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-5.7656E-01 +-0.3623E 00 7.6618E CC

-1.7481E 00 3.9652E-01

-4.67312E-01 +-0.9355CE CC 1.4642E CC

AERFC(94) = 182.00

EH. ATT., DEFLIN, & CABLE TENSION

```

THETA = 35 DEC
DELT A = 25 DEC
FPT CAB. TENSION= 0.155741E+03 IES
BB CAB. TENSION = 0.162C34E C3 IBS
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
-6.4969E-C1 +-5.6079E 00 1.0669E 00 9.3730E-01 1.1200E 00 8.9253E-01 1.15CEB-C1 1.05C2E 00 4.8291E-01
-5.2223E-C1 +-9.4059E 00 1.3273E 00 7.5241E-C1 6.68C1E-01 1.4570E 00 1.4993E 00 5.5437E-02 5.0329E-01 7.0550E-C1
>>> LATERAL/DIRECTIONAL STABILITY <><
REAL IMAGINARY T F/E-SEC 1/T F/E PERIOD-SEC
-9.769CE-C1 +-3.7156E 00 7.0954E-01 1.4054E C0 1.6910E 00 5.5136E-01 6.1146E-01 2.5428E-01 2.3833E 00 1.9168E-01
-1.7402E 00 +-7.C53CE CC 2.5831E-C1 2.5106E C0 8.8583E-01 1.1289E 00 1.1624E 00 2.3828E-01 2.224CE 00 2.1405E-01
-4.7668E-01 +-1.0275E 01 1.4541E 00 6.1714E-C1 6.1714E 00 1.6354E 00 1.6371E 00 4.6343E-02 4.2053E-01 7.4715E-01
AEFC( 94) = 196.00

```

EH. ATT., DEFLIN, & CABLE TENSION

```

THETA = 2.38 DEC
DELT A = -1.40 DEC
FPT CAB. TENSION= 0.167414E C3 IBS
BB CAB. TENSION = 0.196035E 03 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T F/E-SEC 1/T F/E PERIOD-SEC
-6.6675E-C1 +-2.71EEE CC 1.0396E 00 5.6191E-01 1.099E 00 9.C985E-01 9.1602E-01 1.1585E-01 1.0572E 00 4.8056E-C1
-5.0470E-01 +-9.6E66E CC 1.3734E 00 7.2813E-01 6.4865E-01 1.5417E 00 1.5438E 00 5.2C34E-C2 4.723CE-01 7.2081E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<
REAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
-6.7482E-01 +-3.8074E 00 7.1105E-01 1.4064E C0 1.6503E 00 6.0597E-01 6.2551E-01 2.48C3E-C1 2.32CSE 00 2.0015E-01
-1.733CE 00 +-7.4170E 00 3.9996E-01 2.5002E C0 8.4713E-01 1.1805E 00 1.2122E 00 2.2753E-01 2.1180E 00 2.3036E-01
-4.8606E-01 +-1.0E45E 01 1.4260E C0 7.0124E-C1 5.9587E-01 1.6782E 00 1.6800E 00 4.6047E-02 4.1785E-01 7.4854E-01

```

CASE NO: 2 TEST DATA UNSNUBBED SNUBBER
(PLATE CABLE VERTICAL, REEF CABLE FORIZONTAL)
SNUBBERS UNSNUBBED
AC LIFT/ANTI-LIFT CABLE

DATA CFANGE
C 0.0

>>>> ROOT LOCUS VARYING AERCl (94)

AERC(94) = 84.000

EE. ATT., DEPLN, & CABLE TENSION

THETA = 2.26 DEG
DELTA = -0.65 EFG
FRT CAP. TENSION = 0.108811E 03 IBS
EE CAP. TENSION = C.0112032E C3 IBS
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D SEC 1/T H/D PERIOD-SEC UNDNTF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-5.411E-01 + 6.468E 00 1.3792E 00 7.2588E-01 1.1495E 00 8.6991E-01 8.7358E-01 9.1566E-02 8.3157E-01 3.5157E-01
-6.711E-01 + 9.248E 00 1.0329E 00 9.6614E-01 7.5853E-01 1.3183E 00 1.3227E 00 8.0750E-02 7.3424E-01 6.0108E-01
>>> LATERAL/CIRCUMFERENTIAL STABILITY <<<
REAL IMAGINARY T F/T SEC 1/T F/T PERIOD-SEC UNDNTF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-7.7711E-01 + 4.8162E 00 1.1218E 00 1.2971E 00 7.7099E 00 7.8083E-01 1.4540E-01 1.4946E-01 3.6496E-01
-1.2955E 00 + 8.1265E 00 5.371C2-E 00 1.8618E 00 7.7317E-01 1.2934E 00 1.3696E 00 1.5688E-01 1.4355E-01 3.6869E-01
-1.1258E 00 + 9.4575E 00 6.1571E-01 1.6241E 00 6.6078E-01 1.5042E 00 1.5149E 00 1.1827E-01 1.0797E 00 4.7313E-01

AERC(94) = 98.000

EE. ATT., DEPLN, & CABLE TENSION

THETA = 2.28 DEG
DELTA = -0.39 DEG
FRT CAP. TENSION = C.112C4E8E C3 IBS
EE CAP. TENSION = 0.980322E 02 IBS
>>> LONGITUDINAL STABILITY T H/D SEC 1/T H/D PERIOD-SEC UNDNTF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
REAL IMAGINARY T F/T SEC CC 1.2811E CC 7.8C652E 01 1.1159E 00 8.9294E-01 8.9708E-01 9.6000E-02 8.7424E-01 3.5857E-01
-5.411E-01 + 6.468E 00 1.C651 CC 9.1201E-01 7.3242E-01 1.3653E 00 1.3696E 00 7.3462E-02 6.6758E-01 6.2939E-01
>>> LATERAL/CIRCUMFERENTIAL STABILITY <<<
REAL IMAGINARY T H/D SEC 1/H/D PERIOD-SEC UNDNTF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-6.041E-01 + 4.9230E 00 8.6491E-01 1.1562E 00 1.2763E 00 7.8352E-01 7.9383E-01 1.6066E-01 1.4756E-01 3.5857E-01
-1.2535E 00 + 8.4024E 00 5.5439E-01 1.8041E 00 7.4719E-01 1.3373E 00 1.3520E 00 1.4720E-01 1.3491E 00 3.5255E-01
-1.1416E 00 + 9.7465E 00 6.6771E-01 1.6470E 00 6.4466E-01 1.5512E 00 1.5678E 00 1.1613E-01 1.0617E 00 4.7905E-01

AERC(94) = 112.00

PH. ATT., DEPLN, & CABLE TENSION

THETA = 2.37 DEG
DELTA = -0.63 EFG
FRT CAP. TENSION = 0.132159E 03 IBS
EE CAP. TENSION = C.112031E C3 IBS
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D SEC 1/T H/D PERIOD-SEC UNDNTF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-5.7348E-01 + 5.7409E 00 1.1505E 00 1.0945E 00 9.1369E-01 9.1825E-01 9.3947E-02 9.0555E-01 5.3167E-01
-5.999CF-01 + 9.8712E 00 8.6428E-01 7.0627E-01 1.4115E 00 1.4115E 00 6.7377E-02 6.1214E-01 6.5423E-01
>>> LATERAL/CIRCUMFERENTIAL STABILITY <<<
REAL IMAGINARY T F/T SEC 1/T F/T PERIOD-SEC UNDNTF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-8.2059E-01 + 4.555E 00 8.4470E-01 1.1839E 00 1.2569E 00 7.9561E-01 8.0626E-01 1.619R8-01 1.4880E 00 3.5651E-01
-1.2155E 00 + 9.6700E 00 5.6620E-01 1.7600E 00 7.2470E-01 1.3199E 00 1.3935E 00 1.3935E 00 4.1310E-01 4.1310E-01
-1.1531E 00 + 1.0034E 01 6.0112E-01 1.5636E 00 6.2622E-01 1.5589E 00 1.6074E 00 1.7167E-01 1.0418E 0C 4.5E74E-01

AERC(94) = 124.00

EE. ATT., DEPLN, & CABLE TENSION

THETA = 2.42 DEG
DELTA = -1.06 DEG
FRT CAP. TENSION = 0.143632E C3 IBS

EE. ATT. & CABLE TENSION

TEETA	2.42 DEG							
DELTIA	-1.65 DEG							
EST CAF. TENSION=	0.19C527E 03 LBS							
RR CAF. TENSION =	0.182037E 03 IES							
>>> LONGITUDINAL STABILITY <<<								
REAL IMAGINARY T E/D-SEC	1/T E/C	PERIOD-SEC	DAMP-RATIO	DECAY RATIO				
-6.7627E-01	+-6.2708E 00	1.0250E 00	5.7565E-C1	1.0020E 00	9.9803E-01	1.0722E-01	9.7758E-01	5.0783E-01
-4.9429E-01	+-1.C261E C1	1.4C23E CC	7.1311E-C1	6.1235E-01	1.63331E 00	4.8117E-C2	4.3667E-01	7.3884E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<								
REAL IMAGINARY T H/D-SEC	1/T H/C	PERIOD-SEC	DAMP-RATIO	DECAY RATIO				
-6.7343E-01	+-5.3568E 00	7.9359E-C1	1.2601E 00	1.1729E 00	8.5256E-01	8.6382E-01	1.6C32E-01	1.476CE 0C
-1.1466E 00	+-9.8972E 01	6.0453E-01	1.6542E 00	6.3484E-C1	1.5752E 00	1.5857E 00	1.1508E-01	1.0501E 00
-1.1741E CC	+-1.1266E 01	5.5C36E-C1	1.6939E 00	5.5267E-01	1.8094E 00	1.8190E 00	1.C273E-C1	9.3361E-01
AEPIC(94) =	156.00							

EE. ATT., CFFLIN, & CABLE TENSION

THETA	2.45 DEG							
DELTIA	-1.61 DEG							
PRT CAF. TENSION=	0.202213E 03 IES							
RR CAF. TENSION =	C.196037E C3 LBS							
>>> LONGITUDINAL STABILITY <<<								
REAL IMAGINARY T H/D-SEC	1/T H/D	PERIOD-SEC	DAMP-RATIO	DECAY RATIO				
-6.8895E-01	+-6.3623E 00	1.0062E 00	5.9379E-01	9.8756E-01	1.0126E 00	1.0784E-01	9.8174E-01	5.0648E-01
-4.8119E-C1	+-1.0522E 01	1.4405E 00	6.9421E-01	5.9712E-01	1.6747E 00	4.55683E-02	4.1453E-01	7.5026E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<								
REAL IMAGINARY T E/D-SEC	1/T E/C	PERIOD-SEC	DAMP-RATIO	DECAY RATIO				
-8.7919E-C1	+-5.4256E CC	7.6639E-C1	1.2684E 00	1.1581E 00	8.6351E-01	8.7478E-01	1.5996E-01	1.46829E 00
-1.14C72 CC	+-1.0123E 01	6.C767E-C1	1.6456E 00	6.2068E-01	1.6111E 00	1.6213E 0C	1.1197E-C1	1.0214E 00
-1.1764E CC	+-1.1619E 01	5.9322E-01	1.6943E 00	5.4C75E-C1	1.8493E 00	1.8587E 00	1.0056E-01	9.1618E-01
AEPIC(94) =	156.00							

CASE 3 TEST DATA CHANGE CL AND CM ALPHA
FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL
AC SUBEYFS

DATA CHANGE NO LIFT/ANTI-LIFT CABLE

5	5.5000
6	-1.3000
0	C.C

PF. ATT., DEFLIN, & CABLE TENSION

THEIA = 2.54 DEG

DELTA = -2.76 EIG

FRT CAP. TENSION = 0.120742E 03 IES

RF CAP. TENSION = C.14CC53E C3 IBS

>>> YICNGTIDIAN STABILITY <<<

REAL	IMAGINARY	T H/D-SEC	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
-3.965E-01	+4.5501E 00	5.7138E-01	1.3809E 00	7.2418E-01	7.2691E-01	E.6714E-02	7.89CC-E-01
-6.8065E-01	+9.9917E 00	5.0184E 00	5.8197E-C1	6.2EE4E-C1	1.5902E 00	6.7965E-02	6.1750E-01
							6.51E0E-C1

CASE 1 4 TEST DATA FOR NT FUELING HORIZONTAL
 PCIE CABLES HORIZONTAL
 NO SNUBBERS

DATA CHANGE	
5	6.2000
6	-C.ECCCC
70	C.C
74	80.000
81	26.400
87	8.4000
91	C.EECCC
C	C.0

EH. ATT., DEPTH, & CABLE TENSION

THETA = 2.51 DEG

DELTA = -2.12 DEG

SET CABLE TENSION = C.12E-01 C3 TBS

PP CAP. TENSION = 0.140039E 02 IES

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY 1/H-D-SEC 1/T H/D

4.2523E-C1 2.3517E 00

5.5388E-C1 1.C4E4E CC

>>> INTRAL/INTERFACIAL STABILITY <<<

REAL IMAGINARY 1/E-D-SEC 1/T E/D

2.5766E 00 3.8811E-C1

4.8352E-C1 2.0682E C0

7.4816E 00 1.3366E 00

>>> INTRAL/INTERFACIAL STABILITY <<<

REAL IMAGINARY 1/E-I-SEC 1/T E/I

2.3225E 00 4.3057E-01

8.7235E-01 1.1463E 00

6.4573E-C1 1.5486E 00

>>> INTRAL/INTERFACIAL STABILITY <<<

REAL IMAGINARY 1/E-I-SEC 1/T E/I

5.1593E-01 5.3057E-01

1.1688E 00 1.1463E 00

1.952CE-01 1.5486E 00

7.1543E-C1 5.3222E-02

>>> INTRAL/INTERFACIAL STABILITY <<<

REAL IMAGINARY 1/E-I-SEC 1/T E/I

5.9841E 00 5.5C93E-01

1.1688E 00 1.1463E 00

2.8635E-01 1.5486E 00

7.1543E-C1 5.3222E-02

>>> INTRAL/INTERFACIAL STABILITY <<<

REAL IMAGINARY 1/E-I-SEC 1/T E/I

1.5798E-02 1.593E-01

4.8641E 00 5.3057E-01

2.8635E-01 1.5486E 00

7.1543E-C1 5.3222E-02

>>> INTRAL/INTERFACIAL STABILITY <<<

CASE NC= 1 TEST DATA LRC
FACN CAFN VERTICAL, FEAF CAFE FCFZONTAL
NO SNDBRBS

AC 12FL/AFN-LFT CAFE

INPUT DATA AS SPECIFIED IN AERC ARRAY

AERO(1) = 0.0	AFFC(2) = 0.0	AERO(3) = 0.0	AERO(4) = 0.0	AERC(5) = 0.26
AFFC(6) = C.C	AFFC(7) = C.C	AFFC(8) = 0.0	AFFC(9) = -0.0	AERC(10) = 0.180E-01
AFFC(11) = C.1.E	AFFC(12) = 0.35CE-C1	AFFC(13) = 0.0	AFFC(14) = 0.960	AERO(15) = -1.50
AFFC(16) = D.C	AFFC(17) = 0.0	AERO(18) = 0.3	AFFC(19) = -0.730	AERC(20) = -0.350E-01
AFFC(21) = C.111	AERO(22) = C.C	AFFC(23) = 0.190	AFFO(24) = -0.100E-01	AERO(25) = C.C
AFFC(26) = 0.50CE-01	AFFC(27) = -0.920E-01	AERO(28) = 0.0	AERO(29) = 0.0	AERO(30) = C.C
AFFC(31) = C.C	AERO(32) = 0.0	AFFC(33) = 0.0	AERO(34) = 0.0	AERC(35) = 0.0
AFFC(36) = C.C	AERO(37) = C.C	AFFC(38) = 0.0	AFFC(39) = 0.0	AERO(40) = 0.0
AFFC(41) = C.C	AFFC(42) = 0.0	AERO(43) = 0.0	AERO(44) = 0.0	AERO(45) = C.C
AFFC(46) = C.C	AERO(47) = 0.0	AERO(48) = 0.600	AERO(49) = 4.30.	AERC(50) = 4.35
AFFC(51) = C.35CE-C3	AERO(52) = 14.0.	AFFC(53) = 9.16	AERO(54) = 1.40	AERO(55) = 11.5
AFFC(56) = -0.110	AFFC(57) = 1.80	AERO(58) = 14.0	AFFO(59) = 14.0	AEPC(60) = C.0
AFFC(61) = C.0	AERO(62) = C.C	AFFC(63) = 0.0	AFFC(64) = 0.0	AERC(65) = 0.0
AFFC(66) = C.C	AFFC(67) = -55.C	AFFC(68) = 0.0	AFFC(69) = 0.0	AEO(70) = C.0
AZFC(71) = 0.0	AERC(72) = 13.0	AFFO(73) = 215.	AEPG(74) = 0.0	AERC(75) = A0.0
AFFC(76) = C.0	AERO(77) = 175.	AFFC(78) = 0.0	AFFC(79) = 26.4	AERO(80) = C.0
AZFC(81) = C.0	AETC(82) = A.70	AFFO(83) = 4.40	AERO(84) = 8.40	AERO(85) = C.0
AFFC(86) = 0.0	AERO(97) = 0.0	AERO(98) = 0.920	AERO(99) = 0.0	AEPC(90) = 0.880
AFFC(91) = C.C	AERO(92) = C.C	AFFC(93) = 0.880	AFFC(94) = 140.	AERO(95) = 3.00
AZFC(96) = C.0	AFFC(97) = 177.	AFFO(98) = -0.960	AEPG(99) = 0.0	AEPG(100) = 0.0
AFFC(101) = 0.0	AERC(102) = -2.00	AFFO(103) = 3.70	AERO(104) = 0.500E-01	AEPG(105) = 2.00
AFFC(116) = 1.0C	AERO(117) = 2.30	AFFC(118) = 2.00	AEPG(119) = 3.00	AERO(110) = 2.00
AERC(111) = 14.0.	AFFC(112) = 96.0	AFFO(113) = 72.0	AERO(114) = 180.	AERC(115) = -96.0
AFFC(116) = 72.0	AFFC(117) = 80.0	AFFO(118) = 86.0	AERO(119) = 56.0	AFFC(120) = 50.0
AFFC(121) = 5.0C	AERO(122) = 5.0C	AFFC(123) = 0.0	AFFC(124) = 0.0	AERO(125) = 0.0
AFFC(126) = 0.0	AFFC(127) = 0.0	AERO(128) = 0.0	AERO(129) = 0.0	AERO(130) = C.C

>>>> FICT LOCUS VARYING AER(54)

AERC(54) = 44.020

EF. ATT.,LEAVING CABLE TENSION

```

THETA = 2.17 DEG
DELTA = -0.61 DEG
PRT CAF. TENS(CN) = 0.740171E 02 IFS
FF CAF. TENSION = C.8473CE C2 IBS
>>> ICNGITUDINAL STABILITY <<<
PEAL IMAGINARY T H/D-SEC 1/T H/C PERIOD-SEC
-4.117E-01 +-1.5224E-03 1.6362E-03 5.9306E-01 1.3892E-03 7.1976E-01 7.2273E-01 9.0527E-02 8.2357E-01 5.6188E-01
-7.615CE-01 +-0.3156E-03 9.6775E-01 1.1616E-03 0.5559E-01 1.1692E-03 1.0394E-01 9.4733E-01 5.1659E-01
>>> LATERAL/DEFLECTIONAL STABILITY <<<
22AL IMAGINARY T/E-SEC 1/T F/C PERIOD-SEC
-8.0267E-01 +-3.2205E-03 8.6355E-01 1.1580E-03 1.950CE-03 5.1262E-01 5.2830E-01 2.4161E-01 2.2590E-00 2.0891E-01
-1.6927E-01 +-4.0221E-03 3.471E-01 2.9749E-03 1.5618E-03 6.4029E-01 7.1453E-01 6.4386E-01 4.4930E-00 4.4501E-02
-3.9774E-01 +-8.7582E-03 1.7427E-00 5.7378E-01 7.7071E-01 1.2984E-00 1.3000E-00 6.8657E-02 4.8115E-01 7.3674E-01
AERC( 54)= 98.000

```

EF. ATT.,LEAVING CABLE TENSION

```

THETA = 2.17 DEG
DELTA = -0.51 DEG
FF CAF. TENS(CN) = 0.456992E 02 IFS
RR CAF. TENSION = C.8FCE3E C2 IBS
>>> ICNGITUDINAL STABILITY <<<
PEAL IMAGINARY T H/D-SEC 1/T F/C PERIOD-SEC
-4.623E-01 +-0.7755E-03 1.5735E-03 6.63554E-01 1.3256E-03 7.5038E-01 7.5771E-01 9.71C1E-02 8.8355E-01 5.4203E-01
-7.121E-01 +-0.7.6117E-03 9.7310E-01 1.0276E-03 0.2551E-01 1.2114E-03 1.2161E-00 9.3175E-02 8.4632E-01 5.5543E-01
>>> LATERAL/DEFLECTIONAL STABILITY <<<
REAL IMAGINARY T/E-SEC 1/T F/C PERIOD-SEC
-9.1741E-01 +-1.2556E-03 7.5555E-01 1.3235E-03 1.9949E-03 5.1830E-01 5.3847E-01 2.7116E-01 2.5533E-00 1.7033E-01
-1.8645E-01 +-4.5973E-03 3.7116E-01 2.6899E-03 1.3667E-03 7.3136E-01 7.8996E-01 3.7684E-01 3.6769E-00 7.8218E-02
-4.1131E-01 +-8.-0.5155E-03 1.6851E-00 5.9342E-01 7.3933E-01 1.3531E-00 1.3531E-00 4.8388E-02 4.3939E-01 7.3760E-01
AEFC( 54)= 112.000

```

EF. ATT.,LEAVING CABLE TENSION

```

THETA = 2.14 DEG
DELTA = -0.61 DEG
FF CAF. TENSION = C.57373CE C2 IBS
RR CAF. TENSION = 0.112031E 03 IFS
>>> ICNGITUDINAL STABILITY <<<
PEAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
-5.055E-01 +-4.9267E-03 1.3673E-03 7.3136E-03 1.2753E-03 7.8011E-01 7.8825E-01 1.0271E-01 9.3272E-01 5.2387E-01
-6.672E-01 +-7.9156E-03 1.0392E-03 6.62303E-03 7.9347E-03 1.2603E-00 1.2647E-00 8.3938E-02 7.6356E-01 5.8904E-01
>>> LATERAL/DEFLECTIONAL STABILITY <<<
REAL IMAGINARY T/E-SEC 1/T F/C PERIOD-SEC
-9.586CE-01 +-3.3CE1E-03 7.2293E-01 1.3833E-03 1.9028E-03 5.2555E-01 5.4726E-01 2.7884E-01 2.6320E-00 1.6132E-01
-1.8137E-01 +-5.1177E-03 3.8261E-01 2.6123E-03 1.2277E-03 8.1450E-01 8.6398E-01 3.3355E-01 3.2072E-00 1.0828E-01
-4.2165E-01 +-3.3130E-03 1.6354E-03 6.1108E-03 1.4726E-03 1.4726E-00 1.4726E-00 4.3555E-01 4.8C35E-02 7.3920E-01
AERC( 54)= 126.700

```

EF. ATT.,LEAVING CABLE TENSION

```

THETA = 2.26 DEG
DELTA = -0.51 DEG
PRT CAF. TENS(CN) = 0.19046E 03 IFS

```

AERC(54)= 126.700

EF. ATT.,LEAVING CABLE TENSION

```

THETA = 2.26 DEG
DELTA = -0.51 DEG
PRT CAF. TENSION = 0.19046E 03 IFS

```

FF CAF TENSION = 0.12E+16 C3 LBS

<<<

>>>

IMAGINARY

H/D-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

0.7154E-01

9.7154E-01

5.096E-01

6.189E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T E/F

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

0.5811E-01

2.7760E-01

2.6193E-01

1.6224E-01

0.8817E-01

9.3247E-01

3.0477E-01

2.8965E-01

1.3411E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T F/I

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

IMAGINARY

H/D-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T F/I

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

>>>

IMAGINARY

H/D-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

0.9479E-01

1.0479E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T F/I

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

IMAGINARY

H/D-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

0.9479E-01

1.0479E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T F/I

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

IMAGINARY

H/D-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

0.9479E-01

1.0479E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T F/I

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

1.0479E-01

1.0072E-01

8.9957E-01

6.3225E-01

6.4517E-01

>>>

LATERAL/DIRECTIONAL STABILITY

<<<

>>>

IMAGINARY

T F/E-SEC

1/T H/C

PERIOD-SEC

DNAUT-CPS

UNDNAT-CFS

DAMP RATIO

DECAY RATIO

BH. ATT. DEFINING CABLE TENSION

<input type="checkbox"/>	THETA = 2.35 DEG
	DELTA = -1.25 DEG
	EPI CAP. TENSION = 0.1557415 03 TES
	EF CAP. TENSION = C.1F7C4E C3 TBS
>>>	LONGITUDINAL STABILITY <<<
REAL	IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-6.456E-C1	+5.677E-01 1.066E-00 6.3730E-01 1.1204E-00 8.9253E-11 8.9A50E-01 1.1578E-01 1.05C2E-00 4.9291E-01
-5.2223E-C1	+9.4059E-00 1.3273E-00 7.5141E-C1 6.68C1E-01 1.4570E CC 1.4993E-00 5.5337E-02 5.0329E-01 7.05E-0-C1
>>>	LATERAL/DEFLECTIONAL STABILITY <<<
REAL	IMAGINARY T V-C-SIC 1/T E/I PERIOD-SEC DNATF-CPS UNDNAT-CFS DAMP RATIO DECAY RATIO
-5.769E-C1	+3.7156E-01 7.0954E-01 1.4054E CO 1.6510E-00 5.5136E-31 6.1146E-01 2.528E-01 2.3833E 00 1.9168E-01
-1.7402E CO	+7.0954E-01 2.5016E CO 8.8583E-01 1.1289E-00 1.1624E-00 2.3888E-01 2.224C2 00 2.145E-01
-4.7668E-01	+1.0275E-01 1.4501E-00 6.8771E-01 6.1110E-01 1.6354E-00 1.6371E-00 4.6343E-02 4.2053E-01 7.4775E-01
AERC1 q4) = 196.00	

BE. ATT. DEFINING CABLE TENSION

<input type="checkbox"/>	THETA = 2.35 DEG
	DELTA = -1.40 DEG
	EPI CAP. TENSION = C.167414E C3 TES
	EF CAP. TENSION = 0.196035E 03 TES
>>>	LONGITUDINAL STABILITY <<<
REAL	IMAGINARY T V-C-SIC 1/T H/D PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-6.4675E-C1	+5.714EE CC 1.0CEEE CC 5.6191E-C1 1.0561E-00 9.C9851E-01 9.1602E-01 1.0572E-00 4.P05EE-C1
-5.0473E-C1	+5.6EEEE CC 1.3734E CC 7.2413E-01 6.4865E-01 1.5417E 00 1.5438E-02 4.723C3-01 7.2081E-01
>>>	LATERAL/DEFLECTIONAL STABILITY <<<
REAL	IMAGINARY T B/D-SEC 1/T H/E PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-5.7482E-01	+3.8074E-00 7.1105E-01 1.4064E CO 1.6503E-00 6.0597E-01 6.2551E-01 2.46C3-01 2.32C9E-00 2.0015E-01
-1.733CE-01	+7.4170E-01 3.9966E-01 2.5002E CO 8.4713E-01 1.1803E-00 1.2122E-00 2.2753E-01 2.1180E-00 2.3036E-01
-4.9356E-01	+1.C545E-01 1.4260E CO 7.0124E-C1 5.9587E-01 1.6782E-00 1.6800E-00 4.6047E-02 4.1785E-01 7.4854E-01

CASE NO: 2 FEET 1 CABLE INSULATED SUBREF
SUBREF CABLE VERTICAL, REAR CABLE HORIZONTAL
SUBREFS UNNUMBERED
AC LIFT/ANTI-LIFT CABLE
DATA CHANGE
C.C.J



>>>> FOCUT LOCCES VARYING AERCl (c4)

AERC(94) = 94.200

FF. ATT., DEPTN, E CABLE TENSION

THETA = 2.26 DEC

DELTA = -0.66 LFC

FRT CAP. TENSION = 0.102611E 03 IFS

FRT CAE. TENSION = C.012C315E 03 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY 1 H/D-SEC

1/T H/E

PERIOD-SEC

DNATP-CPS

UNDNAT-CPS

DAMP RATIO

DECAY RATIO

-5.025E-01

-0.45E-01

8.69912E-01

8.7358E-01

9.1566E-02

8.1151E-01

5.6116E-01

-6.714E-01

-0.39E-01

9.6614E-01

7.5853E-01

1.3183E-00

1.3227E-00

8.0750E-02

7.3436E-01

6.0108E-01

>>> LATITAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY 1 F/T-SIC

1/T F/T

PERIOD-SEC

DNATP-CPS

UNDNAT-CPS

DAMP RATIO

DECAY RATIO

-7.771E-01

-0.41E-01

1.2971E-00

7.7098E-01

7.8083E-01

1.5840E-01

1.4542E-00

3.6496E-01

-1.292CE-01

-0.1265E-01

1.8618E-00

1.2934E-00

1.3056E-00

1.5684E-01

1.4355E-00

3.6869E-01

-1.1256E-00

-0.9515E-03

6.1571E-01

1.6241E-00

6.6478E-01

1.5042E-00

1.7827E-01

1.0797E-00

4.7313E-01

AERC(c4) = 98.200

FF. ATT., DEPTN, E CABLE TENSICK

THETA = 2.28 DEC

DELTA = -0.30 LEC

FRT CAE. TENSION = C.12C4E-03 IBS

FRT CAP. TENSION = 0.943322E 03 IFS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY 1 F/T-SEC

1/T H/E

PERIOD-SEC

DNATP-CPS

UNDNAT-CPS

DAMP RATIO

DECAY RATIO

-5.411CE-01

-0.47E-01

1.8C65E-01

1.115CE-00

8.9294E-01

8.9708E-01

9.6000E-02

8.7424E-01

5.4547E-01

-6.3216E-01

+0.5766E-01

1.3653E-01

7.3492E-00

6.6758E-01

6.2939E-01

>>> LATITAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY 1 H/D-SEC

1/T H/D

PERIOD-SEC

DNATP-CPS

UNDNAT-CPS

DAMP RATIO

DECAY RATIO

-8.0411E-01

+0.9230E-01

9.6491E-01

1.1562E-00

1.2763E-00

7.8352E-01

7.9383E-01

1.0668E-01

1.4756E-00

3.5957E-01

-1.25C5E-01

+0.4324E-01

5.5433E-01

1.AC041E-00

7.4771E-01

1.3373E-00

1.3520E-00

1.4720E-01

1.3491E-00

3.5255E-01

-1.1416E-01

+0.5747E-01

6.C717E-01

1.6472E-00

1.5512E-00

1.5618E-00

1.7633E-01

1.0617E-00

1.0617E-01

1.7905E-01

FH. ATT., DEPTN, E CABLE TENSICK

THETA = 2.31 DEC

DELTA = -0.63 LEC

FRT CAE. TENSION = C.112C31E 03 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY 1 H/D-SEC

1/T H/E

PERIOD-SEC

DNATP-CPS

UNDNAT-CPS

DAMP RATIO

DECAY RATIO

-7.377E-01

+0.5709E-01

1.1570E-01

8.6428E-01

1.0627E-01

1.4119E-00

1.4151E-00

6.7377E-02

6.1214E-01

>>> LATITAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY 1 F/T-SIC

1/T F/T

PERIOD-SEC

DNATP-CPS

UNDNAT-CPS

DAMP RATIO

DECAY RATIO

-8.2059E-01

+0.44709E-01

1.639E-00

1.256E-00

7.9561E-01

8.0626E-01

1.4880E-00

1.6198E-01

3.5651E-01

-1.2159E-01

+0.46702E-01

5.6620E-01

1.7600E-00

7.2470E-01

1.3799E-00

1.3935E-00

1.2754E-00

4.1310E-01

-1.1531E-01

+0.10301E-01

6.0112E-01

1.6633E-00

6.2E22E-01

1.5969E-00

1.6074E-00

1.7477E-01

1.0418E-00

1.0418E-01

0.8574E-01

0.8574E-01

FF. ATT., DEPTN, E CABLE TENSICK

THETA = 2.32 DEC

DELTA = -1.06 DEC

FRT CAE. TENSION= 0.143E322 C3 IBS

P-CAE. TENSION = 126034E 03 TES

>>> LCONGITUINAL STABILITY <<<

REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.0163E-01	+0.4766E C0	1.1122E CC	E.6167E-01	1.0721E 00	9.3273E-01	9.3762E-01	1.0209E-01	9.3726E-01
-5.7101E-01	+0.4766E C0	1.1213E CC	E.2379E-01	6.8596E-01	1.4578E 00	1.4606E 00	6.2219E-C2	5.65C9E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<								6.5759E-01
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.3588E-01	+0.5073E 00	8.2921E-01	1.2059E C0	1.2316E 00	8.0739E-01	8.1821E-01	1.6258E-01	1.4931E 00
-1.1966E C0	+0.4298E C0	5.7931E-01	1.7262E C0	7.0324E-01	1.4212E 00	1.4339E 00	1.3280E-01	1.2146E 00
-1.1613E C0	+0.4011E C1	1.5754E-02	6.0924E-01	1.6314E-01	1.6518E 00	1.115CE-01	1.02CE-01	4.0590E-C1

AERFC(94) = 149.30

EH. ATT.,DEFLIN.6 CABLE TENSION

THETA = 2.35 DEC								
ELTA = -1.3L DEC								
FRT CAE. TENSION = 0.1555A4E 03 TES								
RF CAE. TENSION = C.14CC34E C2 1BS								
>>> LCONGITUINAL STABILITY <<<								
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.2493E-01	+0.5271E-01	1.1092E 00	5.0116E-01	1.0522E 00	9.5032E-J1	9.5562E-01	1.04CE-01	9.3846E-01
-5.4716E-C1	+0.4412E C0	1.2569E 01	7.8939E-C1	6.6536E-C1	1.5029E 00	1.5055E 00	5.7846E-02	5.1819E-01
>>> LATERAL/DEFLECTIONAL STABILITY <<<								6.94E5E-C1
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-9.4922E-C1	+0.5145E-02	CC	E.1717E-C1	1.2337E C0	1.2211E 00	8.1893E-01	6.2998E-01	1.4626E-01
-1.1786E C0	+0.9.1821E CC	5.8611E-C1	1.7003E-01	6.8429E-01	1.4614E 00	1.4734E 00	1.2132E-01	1.1635E 00
-1.1677E C0	+0.1.2568E-01	5.9334E-01	1.6316E C0	5.9334E-01	1.6494E 00	1.6950E 00	1.0357E-01	4.4642E-01

AERFC(94) = 154.30

EH. ATT.,REFLNE.CABLE TENSICA

THETA = 2.37 DEC								
ELTA = -1.3L DEC								
FRT CAE. TENSION = C.1671ACE C2 1BS								
RF CAE. TENSION = J.155035E 03 TES								
>>> LCONGITUINAL STABILITY <<<								
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.4472E-C1	+0.5774E CC	1.0751E 00	9.3011E-01	1.0344E 00	9.6791E-01	9.7257E-01	1.0551E-01	9.6180E-01
-5.2610E-C1	+0.9.7211E CC	1.3157E CC	7.5602E-C1	6.4533E-01	1.5472E 00	1.5495E 00	5.4113E-C2	5.1342E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<								7.1142E-01
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.5823E-C1	+0.52169E C0	8.0759E-C1	1.2382E C0	1.2044E 00	8.3029E-01	8.4445E-01	1.6234E-01	1.4913E 00
-1.1645E C0	+0.9.4272E C0	5.9502E-01	1.6806E C0	6.6650E-01	1.5004E 00	1.5118E 00	1.2644E-01	1.1201E 00
-1.174CE C0	+0.1.0853E C1	5.5221E-C1	1.68930E C0	5.7889E-01	1.7272E 03	1.7373E 00	1.0723E-01	9.7784E-01

AERFC(94) = 168.20

EH. ATT.,DEFLIN.6 CABLE TENSINA

THETA = 2.40 DEC								
ELTA = -1.4L DEC								
FRT CAE. TENSION = J.179853E 03 TES								
RF CAE. TENSION = C.11E7E4E C3 1ES								
>>> LCONGITUINAL STABILITY <<<								
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.617CE-C1	+0.6115TE C0	1.0075E 00	5.5164E-01	1.0174E 00	9.8290E-01	9.8853E-01	1.0651E-01	9.7126E-01
-5.0935E-01	+0.9.9939E C0	1.3608E C0	7.3464E-C1	6.287CE-C1	1.5590E 00	1.5926E 00	5.0902E-02	5.1050E-01
>>> LATERAL/DEFLECTIONAL STABILITY <<<								5.2558E-C1
REAL	IMAGINARY	H/D-SEC	1/T H/C	PERIOD-SEC	DNATF-CFS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-8.6656E-C1	+0.5873E C0	7.9518E C1	1.2502E C0	1.1664E 00	8.4149E-01	8.5272E-01	1.6174E-01	1.4857E 00
-1.15452 C0	+0.9.6644E C0	6.CC4CF-C1	1.6656E C0	6.5007E-01	1.3283E 00	1.5492E 00	1.1002E-01	1.0627E 00
-1.173CE C0	+0.1.1113E C1	5.9093E-01	1.6922E C0	5.6537E-01	1.7687E 00	1.7786E 00	1.0496E-01	9.5675E-01

AERFC(94) = 182.00

EF. ATT.-REFLTN, & CABLE TENSIC

```

TETA = 2.45 DEG
DELTA = -1.65 DEG
EF CAF. TENSION = C.190527E 0 185
RP CAF. TENSICN = 0.182037E 0 1FS
    >>> LMGITIINL STABILITY <<<
    FINAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
    -6.7527E-01 +6.2708E 00 7.7565E-C1 1.0020E 00 9.9803E-C1 9.758E-01 5.C783E-C1
    -4.9426E-C1 +1.C261E C1 1.4033E CC 7.1311E-C1 6.1235E-01 1.6331E 00 1.635CE 00
    >>> LATERALDISECTIONAL STABILITY <<<
FINAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
    -6.3432E-C1 +5.3568E 00 1.2601E 00 1.1720E 00 8.5256E-01 8.6182E-01 1.6C93E-01
    -1.1466E 00 +9.9972E 01 6.0453E-01 1.6542E 00 6.3464E-C1 1.5752E 00 1.5857E 00
    -1.1741E 00 +1.1369E 01 5.C936E-C1 1.6939E 00 5.5267E-01 1.8094E 00 1.8190E 00
    AER( 94) = 156.20

```

EF. ATT.-REFLTN, & CABLE TENSICN

```

TETA = 2.45 DEG
DELTA = -1.61 IFC
EF CAF. TENSION = 0.202213E 22 IFS
CAF. TENSICN = C.196C37E 0 1BS
    >>> LMGITIINL STABILITY <<<
    FINAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
    -6.7825E-01 +7.3623E 00 1.0062E 00 5.9379E-01 9.8756E-01 1.0126E 00 1.0185E 00
    -4.2116E-C1 +1.0522E C1 1.3405E CC 6.9421E-C1 5.9712E-01 1.6747E 00 1.6764E 00
    >>> LATERALDISECTIONAL STABILITY <<<
FINAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC
    -8.7919E-C1 +5.4256E CC 7.6635E-C1 1.2684E 00 1.1581E 00 8.6351E-01 8.7478E-01 1.4689E 00
    -1.16C72 E 00 +1.0123E 01 6.C67E-C1 1.6456E 00 6.2068E-01 1.6111E 00 1.6232E 00 1.1157E-01
    -1.1744E 00 +1.1619E 01 5.9322E-01 1.6943E 00 5.4C75E-C1 1.E493E 00 1.0056E-01 9.1618E-01 5.2994E-01

```

CASE NO = 3 TEST DATA CHANGE CL AND CM ALPHA
 FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL
 AC SINEPESIS
 NC 1211/ANTI-LIFT CABLE

DATA CHANGE	5 ECCC
5	-1.3030
6	-1.3030
7	-1.3030

```

FF. ATT., DEFNIN.G CABLE TENSION
THEIA = 2.94 DIG
DELTA = -2.7 LEG
PAT CAP. TENSION = 0.120742E 03 IBS
FF.CAP. TENSION = 0.14CCEIE C3 IBS
>>> INGITECINL STATEILITY <<<
PEAL IMAGINARY 1/H*D SEC 1/T H/D
-3.56C5E-01 +-.5501E CO 1.7252E 00 5.7138E-01 1.3809E 00
-6.8065E-01 +-.9.9917E CO 1.0184E 00 5.8197E-01 6.28E42E-01
>>> PERIOD-SEC UNENAT-CP5 DAMP RATIO DECAY RATIO
7.2418P-01 7.2691P-01 6.6714E-02 7.69CC-01
6.7965E-02 6.7502E-01 6.1750E-01 6.1750E-01

```

CASE NC= 4 TEST DATA FFCNT FFLITY ICRTION TAI

NO SNUFFERS

AC LIST/ANTI-LIST CABLE

DATA CHANGE

6.2000

-C.BCCC

7.0 C.C

8.2 .000

9.4 .400

9.8 .4000

9.9 C.ECCC

1.0 C.0

SH. ATT.-DEPOT, F CABLE TENSIC

TEFA = 2.51 DEG

DETA = -2.12 DEG

FET CABLE TENSION = 0.1288E-03 IBS

FP CABLE TENSION = 0.16039E-03 IFS

>>> LINEAR STABILITY <<<

REAL IMAGINARY 1/H-SEC 1/T F/C

0.2523E-01 2.3517E-01 4.2564P CC

5.5388E-01 1.0464P CC

7.8460E-01 1.1274E C0

8.6699E-01 1.2745E C0

9.2815E-02 1.2789E 00

5.2284E-02 7.0841E-01

5.9526E-01

>>> INTERFECTICAN STABILITY <<<

REAL IMAGINARY T.F/L-SEC 1/T F/C

2.5766E-00 3.0811E-C1

2.0322E-01 4.0816E-01

8.7235E-01 6.4573E-C1

1.7467E-00 1.5488E-00

1.7688E-00 1.5508E-00

5.3222E-02 5.3222E-02

4.0311E-01 4.0311E-01

7.1543E-01 7.1543E-01

DAMP RATIO DECAY RATIO

5.1593E-01 5.0841E-00

5.5059E-01 5.0841E-00

1.9552E-01 1.8632E-01

1.8632E-01 2.8632E-01

CASE NO.

1 TEST DATA LRC

PBCNT CABLE VERTICAL, REEF CABLE HORIZONTAL

NO SHUBBERS

NC LIFT/ANTI-LIFT CABLE

INPUT DATA AS SPECIFIED IN AERC ARRAY

AERO(1) = C.0	AERC(2) = 0.0	AERO(3) = 0.0	AERO(4) = 0.0	AERO(5) = 6.26
AERO(6) =-C.81C	AERO(7) = C.C	AERC(8) = 0.0	AERO(9) = -8.00	AERO(10) = 0.180E-01
AERC(11) = C.1C	AFFC(12) = 0.35CE-01	AERC(13) = 0.0	AERO(14) = 0.960	AERO(15) = -1.50
AERO(16) = 3.0	AFFC(17) = 0.0	AERO(18) = 0.0	AERO(19) = -0.730	AERC(20) = -0.350E-01
AERO(21) = C.111	AERO(22) = C.C	AERC(23) =-0.190	AERO(24) =-0.100E-01	AERO(25) = 0.0
AERO(26) = 2.55CE-C1	AFFC(27) =-0.920E-01	AERO(28) = 0.0	AERO(29) = 0.0	AERO(30) = C.C
AFFC(31) = C.C	AERO(32) = 0.0	AERO(33) = 0.0	AERO(34) = 0.0	AERC(35) = 0.0
AERC(36) = C.C	AERO(37) = C.C	AERC(38) = 0.0	AERO(39) = 0.0	AERO(40) = 0.0
AERO(41) = C.C	AFFC(42) = 0.0	AERO(43) = 0.0	AERO(44) = 0.0	AERO(45) = C.C
AERO(46) = C.C	AERO(47) = 0.0	AERO(48) = 0.800	AERO(49) = 4.30	AERC(50) = 4.35
AERO(51) = C.35CE-C3	AERO(52) = 140.	AERC(53) = 9.16	AERO(54) = 1.40	AERO(55) = 11.5
AERC(56) =-0.11C	AFFC(57) = 1.80	AERO(58) = 14.0	AERO(59) = 14.0	AERC(60) = C.0
AERO(61) = C.C	AERO(62) = C.C	AERC(63) = 0.C	AERC(64) = 0.0	AERO(65) = 0.0
AERC(66) = 59.C	AFFC(67) = -59.C	AERC(68) = 0.0	AERO(69) = 0.0	AERO(70) = 0.0
AERO(71) = 0.0	AFFC(72) = 10.0	AERO(73) = 285.	AERO(74) = 0.0	AERO(75) = 80.0
AERO(76) = 0.0	AERO(77) = 175.	AERC(78) = 0.0	AERO(79) = 26.4	AERO(80) = 0.0
AERO(81) = C.C	AFFC(82) = 8.70	AERO(83) = 8.40	AERO(84) = 8.40	AERO(85) = 0.C
AERO(86) = 0.C	AERO(87) = 0.0	AERO(88) = 0.920	AERO(89) = 0.0	AERC(90) = 0.880
AERC(91) = C.C	AERO(92) = C.C	AERC(93) = 0.880	AERO(94) = 140.	AERO(95) = 3.00
AERO(96) = C.0	AFFC(97) = 177.	AERO(98) =-0.960	AERO(99) = 0.0	AERO(100) = 0.0
AERO(101) = 0.0	AERC(102) = -2.00	AERO(103) = 3.00	AERO(104) = 0.500B-01	AERO(105) = 2.00
AERO(106) = 3.0C	AERO(107) = 2.00	AERC(108) = 2.00	AERO(109) = 3.00	AERO(110) = 2.00
AERO(111) = 18.0	AFFC(112) = 96.0	AERO(113) = 72.C	AERO(114) = 180.	AERC(115) = -96.C
AERO(116) = 72.0	AERO(117) = 80.0	AERO(118) = 8C.C	AERO(119) = 50.0	AERO(120) = 50.0
AERO(121) = 5.5C	AERO(122) = 5.0C	AFFC(123) = 0.0	AERC(124) = 0.0	AERO(125) = 0.0
AERO(126) = C.0	AFFC(127) = 0.0	AERO(128) = 0.0	AERO(129) = 0.0	AERO(130) = 0.C

>>> JT LOCUS VARYING AERO(94)

AERO(94) = 84.000

EH. ATT., DEFLTN, & CABLE TENSION

THETA	=	2.20	DEG			
DELTA	=	-0.35	DEG			
PRT CAF. TENSION=	0.740171E 02	IES				
RR CAF. TENSION =	C.84C3CC E C2	IBS				
>>> LONGITUDINAL STABILITY <<<						
REAL IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO
-4.1108E-01	+4.5224E 00	1.6862E 00	5.9306E-01	1.3893E 00	7.1976E-01	9.0527E-02
-7.6359E-01	+7.3066E 00	9.0775E-01	1.1016E 00	8.5994E-01	1.1629E 00	1.0394E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<						
REAL IMAGINARY	T E/D-SEC	1/T E/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO
-8.0267E-01	+4.2295E CC	8.6355E-C1	1.1580E CO	1.9508E CO	5.1262E-01	2.4181E-01
-1.9927E CC	+4.0231E 00	3.4749E-C1	2.8749E 00	1.5618E 00	6.4029E-01	4.4386E-01
-3.9774E-01	+8.1582E 00	1.7427E 00	5.7382E-C1	7.7017E-01	1.2984E 00	1.3000E 00
AERC(94) =	98.000					

EH. ATT., DEFLTN, & CABLE TENSION

THETA	=	2.22	DEG			
DELTA	=	-0.5C	DEG			
PRT CAF. TENSION=	0.856892E 02	IES				
RR CAF. TENSION =	C.9ECC3CE C2	IBS				
>>> LONGITUDINAL STABILITY <<<						
REAL IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO
-4.6201E-01	+4.7355E CO	1.5030E 00	6.6654E-01	1.3256E 00	7.5438E-01	7.5796E-01
-7.1231E-01	+7.6113E 00	9.7310E-01	1.0276E 00	8.2551E-C1	1.2114E 00	9.3179E-02
>>> LATERAL/DIRECTIONAL STABILITY <<<						
REAL IMAGINARY	T E/D-SEC	1/T E/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO
-9.1741E-01	+3.2566E CO	7.5555E-C1	1.3235E 00	1.9294E 00	5.1830E-01	5.3847E-01
-1.8645E CC	+4.5973E 00	3.7176E-01	2.6899E 00	1.3666E 00	7.3168E-01	7.7584E-C1
-4.1133E-01	+8.4915E CC	1.6851E 00	5.9342E-C1	7.39953E-01	1.3515E 00	1.3531E 00
AERC(94) =	112.00					

EH. ATT., DEFLTN, & CABLE TENSION

THETA	=	2.24	DEG			
DELTA	=	-0.61	DEG			
PRT CAF. TENSION=	C.97373CE C2	IHS				
RR CAF. TENSION =	0.112C31E C3	IHS				
>>> LONGITUDINAL STABILITY <<<						
REAL IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO
-5.0694E-01	+4.9267E 00	1.3673E 00	7.3136E-01	1.2753E 00	7.8471E-01	1.0236E-01
-6.6702E-01	+7.9186E 00	1.0392E 00	9.6230E-01	7.9347E-01	1.2603E 00	8.3938E-02
>>> LATERAL/DIRECTIONAL STABILITY <<<						
REAL IMAGINARY	T E/D-SEC	1/T E/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CPS	DAMP RATIO
-9.588CE-C1	+3.3C21E CC	7.2293E-C1	1.3833E 00	1.9028E 00	5.2555E-01	5.4726E-01
-1.8107E 00	+5.1177E CC	3.8281E-C1	2.6123E 00	1.2277E 00	8.1450E-01	8.6398E-01
-4.2385E-01	+8.8130E 00	1.6354E 00	8.1148E-01	7.1295E-01	1.4026E 00	1.4043E 00
AERC(94) =	126.00					

EH. ATT., DEFLTN, & CABLE TENSION

THETA	=	2.26	DEG
DELTA	=	-0.71	DEG
PRT CAF. TENSION=	0.129046E 03	IHS	

EE CAF. TENSION = 3.124E-1F 0 1.5

>>> LONGITUDINAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-5.4556E-00 1.2705E 00 7.8770E-01 1.2344E 00 1.00578E-01 9.7158E-01 5.0 E-01

-6.2802E-01 +8.2248E 00 1.1037E 00 9.0604E-01 7.6393E-01 1.3090E 00 8.1477E-01 6.9215E-01 6.1693E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-5.7347E-01 +3.3689E 00 7.1204E-01 1.4C44E 00 1.8651E 00 5.3618E-01 5.5811E-01 2.7760E-01 2.6193E 00 1.6274E-01

-1.7844E 00 +-5.5866E 00 3.8844E-01 2.5794E 00 1.1259E 00 8.8817E-01 9.3247E-01 3.0457E-01 2.8985E 00 1.3412E-01

-4.3552E-01 +-9.1233E 00 1.5915E 00 6.2833E-01 6.8870E-01 1.4520E 00 1.4537E 00 4.7684E-02 4.3273E-01 7.4086E-01

AERC(94) = 140.00

EE. ATT., DEFINN,E CABLE TENSICK

THETA = 2.28 DEG

DELTA = -C.85 DEG

FET CAF. TENSION= C.12C720E C3 IBS

RR CAB. TENSION = 0.142032E 03 IES

>>> LONGITUDINAL STABILITY <<<

REAL / IMAGINARY T E/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-5.7838E-01 +-2.2364E CC 1.1584E CC 0.3443E-01 1.1959E 00 8.3340E-01 8.3847E-01 1.0979E-01 1.0012E 00 4.9957E-01

-5.9480E-01 +-8.5279E CC 1.1653E CC 8.5812E-01 7.3678E-01 1.3573E 00 1.3606E 00 6.9575E-02 6.3225E-01 6.4517E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-9.7846E-01 +3.4483E 00 7.0841E-01 1.4116E CO 1.8221E 00 5.4882E-01 5.7049E-01 2.7257E-01 2.5721E 00 1.6816E-01

-1.7685E 00 +-6.0008E 00 3.9193E-01 2.5514E CO 1.0471E CO 9.5506E-01 9.9568E-01 2.8269E-01 2.6715E 00 1.5696E-01

-4.4653E-01 +-9.4238E CC 1.5523E CC 6.4420E-01 6.6674E-01 1.4998E 00 1.5015E 00 4.7331E-02 4.2951E-01 7.4251E-01

AERC(94) = 154.00

EE. ATT., DEFINN,E CABLE TENSION

THETA = 2.30 DEG

DELTA = -C.96 EFG

FET CAB. TENSICK= 0.132393E 03 IES

RR CAB. TENSION = 0.154C33E C3 IBS

>>> LONGITUDINAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-6.0617E-01 +-5.3696E CC 1.1435E 00 8.7451E-01 1.1701E 00 8.5460E-01 8.6003E-01 1.1218E-01 1.0233E 00 4.9199E-01

-5.6662E-01 +-8.8262E 00 1.2233E 00 8.1745E-01 7.1168E-01 1.4047E 00 1.4076E 00 6.4065E-02 5.8192E-01 6.6807E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T E/E

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-9.7944E-01 +-3.5246E 00 7.0770E-01 1.4130E CO 1.7776E CO 5.6255E-01 5.8375E-01 2.6704E-01 2.5119E 00 1.7533E-01

-1.7572E 00 +-6.3668E 00 3.5447E-01 2.5351E CO 9.8346E-01 1.0168E 00 1.0546E 00 2.6519E-01 2.4931E 00 1.7762E-01

-4.5699E-01 +-9.7155E 00 1.5168E 00 6.5930E-01 6.4672E-01 1.5463E 00 1.5480E 00 4.6986E-02 4.2638E-01 7.4413E-01

AERC(94) = 168.00

EE. ATT., DEFINN,E CABLE TENSICK

THETA = 2.33 DEG

DELTA = -1.11 DEG

FET CAB. TENSION= 0.144C67E C3 IBS

RR CAB. TENSION = 0.168034E 03 IES

>>> LONGITUDINAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-6.2970E-01 +-4.927E CC 1.10C8E CC 8.0846E-C1 1.1439E 00 8.7479E-01 8.7992E-01 1.1390E-01 1.0392E 00 4.8660E-01

-5.4266E-01 +-6.15CE CC 1.2773E CO 7.8289E-C1 6.8902E-01 1.4513E 00 1.4539E 00 5.94C4E-C2 5.3943E-01 6.8804E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL / IMAGINARY T H/D-SEC 1/T H/C

PERIOD-SEC(

DNATP-CPS UNDNAT-CFS DAME RATIO DECAY RATIO

-5.786CE-01 +-3.6243E 00 7.0831E-01 1.4118E CO 1.7336E CO 5.9749E-01 2.6067E-01 2.4475E 00 1.8332E-01

-1.7481E 00 +-6.7514E 00 3.9652E-01 2.5220E CO 9.3066E-01 1.0745E 00 1.1099E 00 2.5066E-01 2.3471E 00 1.9654E-01

-4.6701E-01 +-9.990E 00 1.4842E CC 6.7376E-C1 6.2838E-01 1.5914E 00 1.5931E 00 4.6656E-02 4.2338E-01 7.4568E-01

AERC(94) = 182.00

```

EH. ATT. LIN. & CABLE TENSION
THETA = -35 DEG
DELTA = -1.25 DEG
PBT CAB. TENSION = 0.155741E 03 IES
RR CAB. TENSION = C.162C34E C3 IBS
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D-SEC 1/T H/D
-6.4969E-C1 +-5.6C79E 00 1.0669E 00 9.3730E-01 PERIOD-SEC
-5.2223E-01 +-9.4059E 00 1.3273E 00 7.5341E-C1 DNATP-CPS UNDNAT-CPS DAMP RATIO
>>> LATERAL/DIRECTATIONAL STABILITY <<<
REAL IMAGINARY T F/E-SEC 1/T F/E
-9.7690E-C1 +-3.7156E C0 7.0954E-01 1.4054E C0 PERIOD-SEC
-1.7402E 00 +-7.C53CE CC 2.5831E-C1 2.5106E C0 DNATP-CPS UNDNAT-CFS DAMP RATIO
-4.7668E-01 +-1.0275E 01 1.4541E 00 6.8771E-C1 6.7749E-01 1.6354E 00 1.6371E 00 4.6343E-02 4.2053E-01 7.4715E-01

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AERO(94) = 196.00

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EH. ATT. ,DEFIN. & CABLE TENSION
THETA = 2.3E DEG
DELTA = -1.40 DEG
PBT CAB. TENSION = C.167414E C3 IBS
RR CAB. TENSION = 0.196035E 03 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T F/E-SEC 1/T F/E
-6.6675E-01 +-5.716EE CC 1.C396E CC 5.6191E-C1 PERIOD-SEC
-5.0470E-01 +-9.6866E CC 1.3734E CC 7.2813E-01 DNATP-CPS UNDNAT-CPS DAMP RATIO
>>> LATERAL/DIRECTATIONAL STABILITY <<<
REAL IMAGINARY T H/D-SEC 1/T H/D
-9.7482E-01 +-3.8074E 00 7.1105E-01 1.4064E C0 PERIOD-SEC
-1.7330E 00 +-7.4170E 00 3.9996E-01 2.5002E C0 DNATP-CPS UNDNAT-CFS DAMP RATIO
-4.8606E-01 +-1.0545E C1 1.4260E CC 7.0124E-C1 5.9587E-01 1.6782E 00 1.6800E 00 4.6047E-02 4.1785E-01 7.4854E-01

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CASE 1

2 TFSI DATA UNSNUBBED SNUBBER

FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL

SNUBBERS UNSNUBBED

AC LIFT/ANTI-LIFT CABLE

DATA CHANGE
C 0.0

>>>> J-T LOCUS VARYING AER(94)

AERO(94) = 84.000

EE. ATT., DEFLIN, & CABLE TENSION

THETA = 2.26 DEG	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
DELTA = -0.66 DEG					
PRT CAF. TENSION = 0.108811E 03 IFS					
RR CAF. TENSION = C.8LC1EE C2 IBS					
>>> LONGITUDINAL STABILITY <<<					
REAL IMAGINARY 1 H/D-SEC	1/T H/D	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO
-5.0259E-01 +*-4.6568E 00	1.3792E 00	7.2508E-01	8.6991E-01	9.1566E-02	8.3351E-01
-6.7106E-01 +*-8.2834E 00	1.0329E 00	9.6614E-01	7.5853E-01	1.3227E 00	8.0750E-02
>>> LATERAL/DIRECTIONAL STABILITY <<<					
REAL IMAGINARY 1 F/T-SHC	1/T F/T	PERIOD-SEC	DNATP-CPS	UNDNAT-CFS	DAMP RATIO
-7.711E-01 +-4.6422E 00	1.1211E 00	1.2971E 00	7.098E-01	1.5840E-01	1.4542E 00
-1.2905E 00 +-8.1265E 00	5.3710E-01	1.8618E 00	7.7317E-01	1.2934E 00	1.3096E 00
-1.1258E 00 +-9.4515E 00	6.1571E-01	1.6241E 00	6.6478E-01	1.5042E 00	1.5149E 00
AERO(94) = 98.000					

EE. ATT., DEFLIN, & CABLE TENSION

THETA = 2.28 DEG	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
DELTA = -0.80 DEG					
FRT CAF. TENSION = C.12C485E C3 IBS					
RR CAF. TENSION = 0.980322E 02 IFS					
>>> LONGITUDINAL STABILITY <<<					
REAL IMAGINARY 1 H/D-SEC	1/T H/D	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO
-5.4110E-01 +-5.6152E 00	1.2810E 00	7.8065E-01	1.1199E 00	8.9294E-01	8.9708E-01
-6.3216E-01 +-8.5766E 00	1.0965E 00	5.1201E-01	7.3242E-01	1.3653E 00	7.3492E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<					
REAL IMAGINARY 1 H/D-SEC	1/T H/D	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO
-8.0414E-01 +-4.9230E 00	9.6491E-01	1.1562E 00	1.2763E 00	7.8352E-01	7.9383E-01
-1.2505E 00 +-8.4024E 00	5.5430E-01	1.8041E 00	7.4779E-01	1.3373E 00	1.3520E 00
-1.1416E 00 +-9.7465E 00	6.0771E-01	1.6477E 00	6.4466E-01	1.5512E 00	1.5618E 00
AERC(94) = 112.00					

EE. ATT., DEFLIN, & CABLE TENSION

THETA = 2.30 DEG	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
DELTA = -0.93 DEG					
PRT CAF. TENSION = 0.132159E 03 IFS					
RR CAF. TENSION = C.112033E C3 IBS					
>>> LONGITUDINAL STABILITY <<<					
REAL IMAGINARY 1 H/D-SEC	1/T H/D	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO
-5.7378E-01 +-5.7409E 00	1.2080E 00	E.2780E-01	9.0985E 00	9.1369E-01	9.1825E-01
-5.9907E-01 +-8.8712E 00	1.1570E 00	8.6428E-01	7.0627E-01	1.4119E 00	1.4151E 00
>>> LATERAL/DIRECTIONAL STABILITY <<<					
REAL IMAGINARY 1 F/T-SHC	1/T F/T	PERIOD-SEC	DNATP-CPS	UNDNAT-CFS	DAMP RATIO
-8.0259E-01 +-4.9555E 00	8.6476E-01	1.1636E 00	1.2569E 00	7.9561E-01	8.0626E-01
-1.2159E 00 +-9.6700E 00	5.6620E-01	1.7600E 00	7.2470E-01	1.3799E 00	1.3935E 00
-1.1531E 00 +-1.0034E 01	6.0711E-01	1.6636E 00	6.2622E-01	1.5569E 00	1.6074E 00
AERC(94) = 126.00					

EE. ATT., DEFLIN, & CABLE TENSION

THETA = 2.32 DEG	PERIOD-SEC	DNATP-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO
DELTA = -1.06 DEG					
FRT CAF. TENSION = 0.143632E C3 IBS					

FR CABLE TENSION = 1.126934E+00

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T E/D-SEC

-6.0143E-01 + -5.8625E-00 1.1525E CC

-5.710E-01 + -9.1597E 00 1.2139E CO

>>> LATERAL/DIRECTIAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-8.3589E-C1 + -5.0730E 00 8.2923E-01

-1.1965E CO + -8.9298E 00 5.7931E-01

-1.1613E 00 + -1.0313E C1 5.9668E-C1

AERC(94) = 140.00

EH. ATT., DEPLTN, & CABLE TENSION

THETA = 2.35 DEG

DELTA = -1.20 DEG

PRT CABLE TENSION = 0.155506E 03 IES

FR CABLE TENSION = C.14CC34E C3 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-6.2483E-01 + -5.9717E 00 1.1093E 00

-5.4716E-01 + -9.4432E 00 1.2668E 00

>>> LATERAL/DIRECTIAL STABILITY <<<

REAL IMAGINARY T E/D-SEC

-8.4823E-C1 + -5.1455E CC

-1.1786E CO + -9.1821E CO

-1.1670E CO + -1.0586E 01

AERO(94) = 154.00

EH. ATT., DEPLTN, & CABLE TENSION

THETA = 2.37 DEG

DELTA = -1.34 DEG

PRT CABLE TENSION = C.16718CE C3 IBS

FR CABLE TENSION = 0.154035E 03 IFS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T E/D-SEC

-6.6472E-C1 + -6.4764E CC

-5.2681E-01 + -9.7214E 00 1.3157E CC

>>> LATERAL/DIRECTIAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-8.5829E-01 + -5.2169E 00 8.0759E-01

-1.1649E CO + -9.4272E 00 5.9502E-01

-1.1707E 00 + -1.0853E C1 5.92C8E-C1

AERC(94) = 168.00

EH. ATT., DEPLTN, & CABLE TENSION

THETA = 2.40 DEG

DELTA = -1.49 DEG

PRT CABLE TENSION = 0.178853E 03 IES

FR CABLE TENSION = C.17EFC3CE C3 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-6.617CE-C1 + -6.1757E 00 1.0475E 00

-5.0935E-01 + -9.9939E 00 1.3608E 00

>>> LATERAL/DIRECTIAL STABILITY <<<

REAL IMAGINARY T E/D-SEC

-8.6656E-C1 + -5.2873E CC

-1.1545E CO + -9.6654E 00 6.0C4CE-C1

-1.173CE CO + -1.113E 01 5.9093E-01

EE. ATT., LEFFLTNE CABLE TENSICK

THETA = 45 DEG
DELTA = -1.65 DEG
PRT CAF. TENSION = 0.190527E 03 IBS

RR CAF. TENSICK = 0.182037E 03 IFS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T E/I-SFC 1/T H/D

0.0250E 00 5.7565E-C1

PERIOD-SEC 0.0020E 00 9.9803E-C1

DAMP RATIO 1.0722E-01 9.7758E-01

DECRY RATIC 4.8117E-C2 4.3667E-01

-6.7627E-01 +-6.2708E 00 1.0250E 00 5.1331E 00 1.6350E 00 4.3884E-01

-4.9429E-01 +-1.0261E 01 1.4C23E CC 7.1311E-C1 6.1235E-01 4.3667E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY T H/D-SFC 1/T H/D

0.0453E 00 1.2601E 00 1.1729F 00 8.5256E-01

PERIOD-SEC 0.0045E 00 9.9359E-C1 6.3484E-C1 8.6382E-01

DAMP RATIO 1.6C93E-01 1.47E00 3.5898E-01

DECRY RATIC 1.508E-01 1.0501E 00 4.E292E-01

-6.7343E-C1 +-5.3568E 00 7.9359E-C1 1.6542E CO 1.5752E 00 1.5857E 00

-1.1466E 00 +-9.8972E 00 6.0453E-01 1.8094E 00 1.8190E 00 1.8273E-01

-1.1741E 00 +-1.1369E 01 5.5C36E-C1 1.6939E 00 5.5267E-01 9.3616E-01

AERC(94) = 196.00

EE. ATT., LEFFLTNE CABLE TENSICK

THETA = 2.45 DEG

DELTA = -1.61 DEG

PRT CAF. TENSION = 0.202213E 03 IFS

RR CAF. TENSICK = C.196C37E C3 IBS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY T H/D-SFC 1/T H/D

0.0062E 00 5.9379E-01 9.8756E-01

PERIOD-SEC 0.0126E 00 1.0764E 00 1.0764E-01

DAMP RATIO 9.8143E-01 5.0648E-01

DECRY RATIC 4.5683E-02 4.1453E-01 7.5026E-01

-6.8885E-01 +-6.3623E 00 1.0062E 00 5.9421E-01 5.9712E-01

PERIOD-SEC 0.0126E 00 1.6747E 00 1.6747E 00

DAMP RATIO 4.5683E-02 4.1453E-01 7.5026E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<

REAL IMAGINARY T E/I-SFC 1/T E/D

0.0405E 00 1.2684E CO 1.1581E 00 8.6351E-01

PERIOD-SEC 0.0040E 00 8.7473E 00 1.5996E-01

DAMP RATIO 1.4689E 00 3.6126E-01

DECRY RATIC 1.1197E-C1 1.6213E 00 1.0214E 00

-1.1407E 00 +-1.0123E 01 6.C767E-C1 6.2068E-01 1.6111E 00 4.9264E-01

-1.1741E 00 +-1.1619E 01 5.9022E-01 1.6943E 00 1.8493E 00 1.8587E 00

PERIOD-SEC 0.0056E 00 9.1618E-01 9.1618E-01

DAMP RATIO 5.2991E-01 5.2991E-01

CASE NO	3	TEST DATA CHANGE CL AND CM ALPHA
FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL WC SUBBEES		
NC LIFT/ANTI-LIFT CABLE		
DATA CHANGE		
5 5.50CC		
6 -1.3000		
0 C.C		

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FF. ATT., DEF LIN, & CABLE TENSION
THETA = 2.94 DIG
DELTA = -2.78 DEG
PRT CAP. TENSION= 0.120742E 03 IES
RB CAF. TENSION = C.14CC53E C3 IBS
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC ENATI-CPS UNENAT-CPS DAMP RATIO DECAY RATIO
-3.96C5E-C1 +4.5501E 00 1.75C2E 00 5.7138E-01 1.3809E 00 7.2418E-01 7.2691E-01 E.6714E-02 7.89CCB-01 5.7874E-01
-6.8065E-01 +9.9917E 00 1.0184E 00 5.8197E-C1 6.28E4E-C1 1.5902E 00 1.5939E 00 6.7965E-02 6.1750E-01 6.5180E-01

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CASE NO = 1 TEST DATA ITC
FOR CABLE VERTICAL, BEAM CABLE HORIZONTAL
NO SHOCKERS

NC TYPE/AMPLITUDE CABLE

INPUT DATA AS SPECIFIED IN AERC ARFAY

AERO(1) = 0.0	AFFC(2) = 0.0	AERO(3) = 0.0	AERO(4) = 0.0	AERC(5) = 0.26
AERO(6) = -0.10	AERC(7) = 0.0	AFFC(8) = 0.0	AERC(9) = -0.00	AERC(10) = 0.180E-01
AERD(11) = 0.10	AFFC(12) = 0.35CE-01	AFFC(13) = 0.0	AERC(14) = 0.960	AERD(15) = 1.50
AERC(16) = 2.0	AFFC(17) = 0.0	AERO(18) = C.0	AERD(19) = -0.730	AERC(20) = -0.350E-01
AERO(21) = 0.111	AERD(22) = C.0	AERC(23) = -0.190	AERO(24) = -0.100E-01	AERO(25) = C.C
AERO(26) = 2.53CE-01	AFFC(27) = -0.920E-01	AERO(28) = C.0	AERO(29) = 0.0	AERO(30) = C.C
AERC(31) = 0.0	AERD(32) = 0.0	AEOF(33) = 0.0	AERO(34) = 0.0	AERC(35) = 0.0
AERC(36) = C.0	AEDQ(37) = C.0	AFFC(38) = 0.0	AERC(39) = 0.0	AERO(40) = 0.0
AERC(41) = C.0	AFFC(42) = 0.0	AERD(43) = 0.0	AERO(44) = 0.0	AERO(45) = C.C
AFFC(46) = C.0	AERQ(47) = 0.0	AERO(48) = 0.87C	AEO(49) = 4.30	AERC(50) = 4.35
AERO(51) = C.35CE-C3	AERD(52) = 14.0	AERC(53) = 9.16	AERO(54) = 1.40	AERO(55) = 11.5
AERC(56) = -0.11C	AEOF(57) = 1.80	AERO(58) = 14.0	AERO(59) = 14.0	AERC(60) = C.0
AERO(61) = C.0	AERO(62) = C.0	AFFC(63) = 0.0	AERC(64) = 0.0	AERC(65) = 0.0
AERC(66) = 50.0	AFFC(67) = -50.0	AERC(68) = 0.0	AERC(69) = 0.0	AERO(70) = C.C
AFFC(71) = 2.0	AFFC(72) = 10.0	AEOF(73) = 2.65	AERO(74) = 0.0	AERC(75) = 90.0
AERC(76) = 2.0	AFFC(77) = 17.5	AFFC(78) = 0.0	AERC(79) = 26.4	AERO(80) = C.0
AERO(81) = C.0	AFFC(82) = 8.00	AEOF(83) = 8.40	AERO(84) = 8.40	AERO(85) = 0.C
AERD(86) = 0.0	AERO(87) = 0.0	AERO(88) = 0.920	AERO(89) = 0.0	AERD(90) = 0.880
AERC(91) = C.0	AERO(92) = C.0	AERD(93) = 0.880	AFFC(94) = 140.	AERO(95) = 3.00
AERD(96) = C.0	AFFC(97) = 177.	AEOF(98) = -0.563	AERC(99) = 0.0	AERD(100) = 0.C
AERC(101) = 3.0	AEOF(102) = -2.00	AERD(103) = 3.0C	AEO(104) = 0.500E-01	AERC(105) = 2.00
AERD(106) = 2.0C	AEOF(107) = 2.0C	AEOF(108) = 2.00	AERC(109) = 3.00	AERO(110) = 2.0C
AERO(111) = 18.0	AFFC(112) = 96.0	AERD(113) = 72.0	AERO(114) = 180.	AERC(115) = -96.0
AERO(116) = 72.0	AFFC(117) = 80.0	AERO(118) = 8C.C	AERO(119) = 50.0	AERD(120) = 50.0
AERO(121) = 5.0C	AERO(122) = 5.0C	AERC(123) = 0.0	AERC(124) = 0.0	AERO(125) = 0.0
AERO(126) = 0.0	AFFC(127) = 0.0	AERO(128) = 0.0	AERO(129) = 0.0	AERO(130) = C.C

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ATT. - REITIN SCABIE TENCION

EH. ATT., DEFLLN. & CABLE TENSION
 THETA = 2.22 SEC
 DELTA = -0.5E-01
 FRI.CAP. TENSION = 0.256292E-02 IES
 FR CAF. TENSION = 0.256292E-02 IES
 >>> LONGITUDINAL STABILITY <<<
 REAL IMAGINARY T H/E-SFC 1/T F/L PERIOD-SEC
 -4.6231E-01 + -0.7222E-01 6.6554E-01 1.3256E-00 7.5438E-01 7.5796E-01 9.714E-02 8.8356E-01 5.4203E-01
 -7.1231E-01 + -7.6113E-01 9.7310E-01 1.0276E-00 6.2551E-01 1.2114E-00 1.2167E-00 9.3179E-02 8.4832E-01 5.5543E-01
 >>> LATERAL/DIRECTIONAL STABILITY <<<
 REAL IMAGINARY T H/E-SFC 1/T F/L PERIOD-SEC
 -9.1741E-01 + -3.2556E-01 7.5555E-01 1.3235E-00 1.9294E-00 5.1830E-01 5.3847E-01 2.7116E-01 2.5536E-01 1.7033E-01
 -1.8645P-01 + -4.5973E-01 3.7176E-01 2.6895E-00 1.3667E-00 7.3168E-01 7.8956E-01 3.7564E-01 3.6764E-01 7.8218E-02
 -4.1133E-01 + -8.4915E-01 1.6851E-00 5.9342E-01 7.3553E-01 1.3533E-00 1.3533E-00 4.8384E-02 4.3909E-01 7.376CE-01
 A EFC (94) = 112.00

ATT. FEELIN' S CIRCLE FUNCTIONS

EE. ATT., REFLIN, & CABLE TENSION
 THEA = 2.42 TEC
 DELTA = -0.61 DEC
 FRT CAF. TENSION = C. 73730E CZ IRS
 RR CAF. TENSION = 0.112031E CZ IRS
 >>> LONGITUDINAL STABILITY <<<
 PEAL IMAGINARY T H/D-SEC 1/T H/D PERIOD-SEC DNATE-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
 -5.026E-01 + -0.9267E-01 1.2577E-01 7.3136E-01 1.2753E-01 7.8411E-01 7.8925E-01 1.0236E-01 9.3272E-01 5.2387E-01
 -6.6725E-01 + -7.9186E-01 1.0362E-01 5.6230E-01 7.9347E-01 1.2603E-01 1.2647E-00 8.3938E-02 7.6355E-01 5.6904E-01

>>> LATERAL/DIRECTIONAL STABILITY <<<
 REAL IMAGINARY T H/L-SEC 1/T F/L PERIOD-SEC DNATE-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
 -9.5280E-01 + -3.3521E-01 7.2253E-01 1.3833E-00 1.9028E-00 5.2555E-01 5.4726E-01 2.7884E-01 2.6320E-00 1.6132E-01
 -1.8107E-01 + -5.1177E-01 3.8261E-01 2.6123E-00 1.2277E-00 8.1450E-01 8.6398E-01 3.3355E-01 3.2072E-00 1.0828E-01
 -4.21365E-01 + -8.9130E-01 1.6354E-00 6.1148E-01 7.1295E-01 1.4026E-00 1.4043E-00 4.8039E-02 4.3555E-01 7.3920E-01

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BE. ATT. DEPLTN. & CABLE TENSION

THETA =	2.26 DEG
DELTA =	-0.3 DEG
PPM CABLE TENSION =	0.100065 N/25

	H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
REAL IMAGINARY	1.2700E-00	7.3707E-01	1.2344E-01	8.1477E-01	1.0037E-01	9.7154E-01	0.9065E-01
REAL IMAGINARY	1.1037E-02	5.0604E-01	7.6393E-01	1.309CE-00	1.3128E-00	7.6136E-02	6.9215E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<							
REAL IMAGINARY	1/T H/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-5.7347E-01	7.1204E-01	1.4044E-00	1.8651E-00	5.3618E-01	5.5811E-01	2.7760E-01	2.6193E-00
-1.7844E-00	2.5744E-00	1.1259E-00	8.8817E-01	9.3247E-01	3.0457R-01	1.0457R-01	2.8965E-00
-4.3552E-01	6.2833E-01	6.8670E-01	1.4520E-00	1.4537E-00	4.7664E-02	4.3273E-01	7.4086E-01

AEPC(94) = 148.20

FF. ATT., DEFINITE, CABLE TENSION

	T H/D-SEC	1/T H/D-SEC	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
REAL IMAGINARY	1.1594E-01	8.3043E-01	1.1950E-00	8.3340E-01	8.3847E-01	1.0979E-01	1.0012E-00
-5.9490E-01	8.5812E-01	7.3673E-01	1.3573E-00	1.3606E-00	6.9579E-02	6.3225E-01	6.4517E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<							
REAL IMAGINARY	1/T H/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-5.7866E-01	7.0841E-01	1.4116E-00	1.8221E-00	5.4882E-01	5.7049E-01	2.7257E-01	2.5721E-00
-1.7685E-00	2.5514E-00	1.0471E-00	9.5506E-01	9.9568E-01	2.8269E-01	2.6715E-00	1.5696E-01
-4.4633E-01	6.5523E-01	6.4420E-01	1.4998E-00	1.5015E-00	4.7331E-02	4.2951E-01	7.4251E-01

AEPC(94) = 154.00

FF. ATT., DEFINITE, CABLE TENSION

	T H/D-SEC	1/T H/E	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
REAL IMAGINARY	1.1403E-00	8.7451E-01	1.1771E-00	8.5460E-01	8.6003E-01	1.1211E-01	1.0233E-00
-5.6662E-01	1.2233E-01	8.1745E-01	7.1168E-00	1.4076E-00	6.4065E-02	5.8192E-01	6.6807E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<							
REAL IMAGINARY	1/T H/D-SEC	1/T F/H	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.0617E-01	7.0770E-01	1.4130E-00	1.7776E-00	5.6255E-01	5.8375E-01	2.6704E-01	2.5119E-00
-1.7572E-01	2.5351E-00	9.8346E-01	1.0168E-00	1.0546E-00	2.6515E-01	2.4931E-00	1.7533E-01
-4.5655E-01	6.5930E-01	6.4672E-01	1.5063E-00	1.5480E-00	4.6986E-02	4.2638E-01	7.4762E-01

AEPC(94) = 168.00

FF. ATT., DEFINITE, CABLE TENSION

	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
REAL IMAGINARY	1.1446E-00	8.0781E-01	1.7336E-00	5.7683E-01	5.9749E-01	2.6667E-01	2.4475E-00
-5.4266E-01	1.2773E-00	7.9289E-01	6.8902E-01	1.4513E-00	1.4539F-00	5.9444E-02	5.3943E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<							
REAL IMAGINARY	1/T H/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.2970E-01	7.0831E-01	1.4118E-00	1.7336E-00	5.7683E-01	5.9749E-01	2.6667E-01	2.4475E-00
-1.7481E-00	2.5220E-00	9.3066E-01	1.0745E-00	1.1099E-00	2.5066E-01	2.3471E-00	1.9654E-01
-4.6791E-01	6.7376E-01	6.2838E-01	1.5914E-00	1.5931E-00	4.6666E-02	4.2333E-01	7.4568E-01

AEPC(94) = 182.00

BH. ATT., STIFFN., & CABLE TENSION

THETA = 2.35 DEG
DETA = -1.25 DFC
FPT.CAP.TENSION= 0.155741E-03 IFS
RR.CAP.TENSION= 0.162034E-03 IFS

>>> LONGITUDINAL STABILITY <<<

REAL IMAGINARY H/D-SEC 1/T H/D PERIOD-SEC UNDANT-CPS DAMP RATIO DECAY RATIO
-6.4969E-C1 + -5.6779E-03 1.3670E-03 9.3730E-01 1.1204E-00 8.9253E-01 1.15C8E-C1 1.05C2E-00 4.8291E-01
-5.2223E-C1 + -9.4059E-03 1.3273E-03 7.5341E-01 6.68C1E-01 1.4993E-00 5.5437E-02 5.0329E-01 7.0550E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<
REAL IMAGINARY H/D-SEC 1/T H/D PERIOD-SEC UNDANT-CPS DAMP RATIO DECAY RATIO
-9.769CE-C1 + -3.7156E-03 7.0954E-01 1.4094E-00 1.6910E-00 5.5136E-01 6.1146E-01 2.5428E-01 2.3833E-00 1.9168E-01
-1.7492E-00 + -7.0930E-03 3.5631E-01 2.5106E-00 8.8583E-01 1.1289E-00 1.1624E-00 2.3828E-01 2.224C2-00 2.1405E-01
-4.7668E-C1 + -1.3275E-01 1.45C1E-00 6.8771E-01 6.1149E-01 1.6334E-00 1.6371E-00 4.6343E-02 4.2053E-01 7.4715E-01

AERC(L 94) = 196.00

BH. ATT., DEFLTN., & CABLE TENSION

THETA = 2.35 DEG
DETA = -1.4C DFC
FPT.CAP.TENSION= 0.167414E-03 IFS
RR.CAP.TENSION= 0.196335E-03 IFS
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY H/D-SEC 1/T H/D PERIOD-SEC UNDANT-CPS DAMP RATIO DECAY RATIO
-6.6675E-C1 + -2.7166E-03 1.3733E-03 9.6191E-01 1.0891E-00 9.0985E-01 1.1585E-01 1.0572E-00 4.8056E-01
-5.0472E-C1 + -9.664E-03 1.3734E-03 7.2913E-01 6.48865E-01 1.5417E-00 5.2C34E-02 4.723CE-01 7.2081E-01
>>> LATERAL/DIRECTIONAL STABILITY <<<
REAL IMAGINARY H/D-SEC 1/T H/D PERIOD-SEC UNDANT-CPS DAMP RATIO DECAY RATIO
-5.7482E-01 + -3.8074E-03 7.11105E-01 1.4064E-00 1.6503E-00 6.0597E-01 6.2551E-01 2.48C3E-01 2.32C5E-00 2.0015E-01
-1.7333CE-00 + -7.4170E-03 3.9906E-01 2.5002E-00 8.4713E-01 1.1805E-00 1.2122E-00 2.2753E-01 2.1180E-00 2.3036E-01
-4.8606E-01 + -1.0545E-03 1.42460E-03 7.0124E-01 5.9587E-01 1.6782E-00 1.68C0E-00 4.6047E-02 4.17E5E-01 7.4854E-01

CASE 2 TEST DATA IN NUMBERED SNUBBED
FRCM CABLE VERTICAL, REEF CABLE HORIZONTAL
SNUBBED UNSURED
AC LIFF/ANTI-LIFF CABLE

DATA CHANGE
C.C.

>>> .POST INCUS VARYING AFFECT (S4)

AERFC(S4) = 94.700

EE. ATT., DEFLN, & CABLE TENSION

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THETA = 2.26 DEG
DELTA = -0.66 DEG
FPT CAP. TENS/CN = 0.103811E 02 IES
RF CAF. TENS/CN = 0.103811E 02 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY 1/T H/D PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-5.07E-01 + 5.07E-01 1.3792E 00 1.2570E-01 8.6991E-01 8.7359E-01 8.1566E-02 8.3351E-01 5.5116E-01
-6.712E-01 + -9.203E 00 1.0320E 00 9.6181E-01 7.5653E-01 1.3183E 00 1.3227E 00 8.0750E-02 7.3436E-01 6.C1C8E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<
REAL IMAGINARY 1/T F/L-SFC PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-7.7711E-01 + -4.842E 00 6.9195E-01 1.1211E 00 1.2971E 00 7.098E-01 7.8083E-01 1.4542E 00 3.6496E-01
-1.2905E 00 + -8.1265E 00 5.371CE-01 1.0618E 00 7.7317E-01 1.2934E 00 1.3096E 00 1.5684E-01 3.6869E-01
-1.1258E 00 + -9.4515E 00 6.1571E-01 1.0224E 00 6.6478E-01 1.5149E 00 1.1827E-01 1.0797E 00 4.7313E-01
AERFC( S4 ) = 95.200

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EE. ATT., DEFLN, & CABLE TENSION

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THETA = 2.26 DEG
DELTA = -0.50 DEG
FPT CAP. TENS/CN = 0.1242E 02 IES
RF CAF. TENS/CN = 0.982322E 02 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY 1/T F/L-SFC PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-5.4116E-01 + -6.71CE-00 7.8765E-01 1.1159E 00 9.9294E-01 8.9708E-01 9.6060E-02 8.7424E-01 5.4554E-01
-6.3214E-01 + -6.578E-00 1.0665E 00 9.12C1E-01 7.3224E-01 1.3653E 00 1.369CE 00 7.3462E-02 6.6758E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<
REAL IMAGINARY 1/T H/D-SEC PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-6.0141E-01 + -9.230E 00 9.6491E-01 1.1562E 00 1.2763E 00 7.8352E-01 7.9383E-01 1.6068E-01 3.5957E-01
-1.25C5E-01 + -9.4024E 00 5.5430E-01 1.8041E 00 7.4779E-01 1.3373E 00 1.3520E 00 1.4720E-01 3.5255E-01
-1.141CE 00 + -9.7465E 00 6.C717E-01 1.6470E 00 6.4466E-01 1.5512E 00 1.5618E 00 1.1633E-01 4.7935E-01
AERFC( S4 ) = 112.00

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EE. ATT., DEFLN, & CABLE TENSION

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THETA = 2.31 DEG
DELTA = -0.63 DEG
FPT CAP. TENS/CN = 0.132159E 02 IES
RF CAF. TENS/CN = 0.112033E 02 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY 1/T H/D-SEC PERIOD-SEC DNATF-CPS UNDNAT-CPS DAMP RATIO DECAY RATIO
-5.7377E-01 + -5.7409E 00 1.2750E 00 8.2780E-01 9.1369E-01 9.1825E-01 9.9452E-02 9.05567E-01
-5.6077E-01 + -9.3712E 00 1.1570E 00 8.64285-01 7.0E27E-01 1.4115E 01 1.4151E 00 6.7377E-02 6.1214E-01 6.5423E-01
>>> LATERAL/DIRECTATIONAL STABILITY <<<
REAL IMAGINARY 1/T F/L-SFC PERIOD-SEC DNATF-CPS UNDNAT-CBS DAMP RATIO DECAY RATIO
-8.2059E-01 + -4.999CE 00 8.447CE-01 1.1E39E-00 1.2569E 00 7.5561E-01 8.0626E-01 1.6198E-01 1.4880E 00 3.5651E-01
-1.2159E 00 + -9.6700E 00 5.662CE-01 1.7600E 00 7.2470E-01 1.3799E 00 1.3935E 00 1.3933E-01 1.2754E 00 4.1310E-01
-1.1531E 00 + -1.0034E 01 6.0112E-01 1.6636E 00 6.2622E-01 1.5969E 00 1.6074E 00 1.17417E-01 1.0418E 00 4.8574E-01
AERFC( S4 ) = 126.00

```

EE. ATT., DEFLN, & CABLE TENSION

```

THETA = 2.32 DEG
DELTA = -0.66 DEG
FPT CAP. TENS/CN = 0.132159E 02 IES
RF CAF. TENS/CN = 0.112033E 02 IES

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END / STABILITY <<<

REAL	IMAGINARY	T F/L-SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.0141E-01	+ 5.4773E-03	1.1775E-01	1.0721E-01	9.3273E-01	9.3762E-01	1.0206E-01	9.3726E-01	e -477E-01
-5.7101E-01	+ 5.1507E-03	1.2115E-01	6.8596E-01	1.4579E-01	1.4666E-01	6.2219E-01	5.6509E-01	5.591E-01
>>> LATERAL/DEFECTONAL STABILITY <<<								
REAL	IMAGINARY	T H/D- SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-8.3589E-01	+ 5.0730E-01	9.2923E-01	1.2059E-01	1.2386E-01	8.0739E-01	8.1827E-01	1.6258E-01	1.4936E-01
-1.1965E-01	+ 8.3298E-01	5.7931E-01	1.7626E-01	7.0362E-01	1.4212E-01	1.4339E-01	1.3280E-01	3.5512E-01
-1.1613E-01	+ 1.0313E-01	5.9667E-01	1.6754E-01	6.0924E-01	1.6414E-01	1.6518E-01	1.115CE-01	4.3090E-01
AERFC(94) = 140.00								4.9287E-01

EH. ATT..DEFINN.6 CABLE TENSION

THETA = 2.35 DEG	DELTA = -1.20 DEG	FRT CAP. TENSCH = 0.155506E-03 IES	FF CAB. TENSION = 0.160734E-03 IES	REAL	IMAGINARY	T H/D- SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.2432E-01	+ 5.8717E-01	1.1093E-01	9.0116E-01	1.0522E-01	9.5043E-01	9.5562E-01	1.0406E-01	9.4846E-01	5.1819E-01	5.0486E-01	5.0486E-01	
-5.6716E-01	+ 0.6432E-01	1.2668E-01	7.8639E-01	6.6536E-01	1.5029E-01	1.5055E-01	5.7846E-02	5.2523E-01	6.9485E-01	6.9485E-01	6.9485E-01	
>>> LATERAL/DEFECTONAL STABILITY <<<												
REAL	IMAGINARY	T H/D- SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO				
-8.4923E-01	+ 5.1455E-01	8.1717E-01	1.2237E-01	1.2211E-01	8.2998E-01	8.6265E-01	1.4943E-01	1.4943E-01	3.5495E-01	3.5495E-01	3.5495E-01	
-1.1868E-01	+ 9.1821E-01	5.8811E-01	1.7036E-01	6.8429E-01	1.4614E-01	1.4734E-01	1.2732E-01	1.1635E-01	4.4642E-01	4.4642E-01	4.4642E-01	
-1.1670E-01	+ 1.7586E-01	5.9398E-01	1.6826E-01	5.9354E-01	1.6948E-01	1.6950E-01	1.0957E-01	9.9926E-01	5.0026E-01	5.0026E-01	5.0026E-01	
AERFC(95) = 154.00												

EH. ATT..DEFINN.6 CABLE TENSION

THETA = 2.37 DEG	DELTA = -1.34 DEG	FRT CAP. TENSCH = 0.16712CE-03 IES	FF CAB. TENSION = 0.154035E-03 IES	REAL	IMAGINARY	T F/L-SEC	1/T H/I	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.4672E-01	+ 5.7774E-01	1.07751E-01	9.30145E-01	1.0344E-01	9.6709E-01	9.7251E-01	1.0551E-01	9.6180E-01	5.1342E-01	5.1342E-01	5.1342E-01	
-5.2641E-01	+ 2.7214E-01	1.3157E-01	7.60C35E-01	6.46333E-01	1.5472E-01	1.5495E-01	5.4113E-02	4.5123E-01	7.1142E-01	7.1142E-01	7.1142E-01	
>>> LATERAL/DEFECTONAL STABILITY <<<												
REAL	IMAGINARY	T H/D- SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO				
-6.5629E-01	+ 5.2169E-01	8.0759E-01	1.2382E-01	1.2044E-01	8.3029E-01	8.4145E-01	1.6234E-01	1.4913E-01	3.5568E-01	3.5568E-01	3.5568E-01	
-1.1649E-01	+ 9.4272E-01	5.9502E-01	1.6606E-01	6.665CE-01	1.5004E-01	1.5118E-01	1.2264E-01	1.1201E-01	4.6005E-01	4.6005E-01	4.6005E-01	
-1.1707E-01	+ 1.0333E-01	5.9209E-01	1.6890E-01	5.7896E-01	1.7272E-01	1.7373E-01	1.0725E-01	9.7784E-01	5.0774E-01	5.0774E-01	5.0774E-01	
AERFC(94) = 168.00												

EH. ATT..DEFINN.6 CABLE TENSION

THETA = 2.42 DEG	DELTA = -1.45 DEG	FRT CAP. TENSCH = 0.178853E-03 IES	FF CAB. TENSION = 0.166336E-03 IES	REAL	IMAGINARY	T H/D- SEC	1/T H/C	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO
-6.6170E-01	+ 5.1757E-01	1.0475E-01	9.5467E-01	1.0174E-01	9.8290E-01	9.8853E-01	1.0654E-01	9.7124E-01	5.1077E-01	5.5708E-01	5.5708E-01	
-5.0255E-01	+ 9.4939E-01	1.3600E-01	7.3464E-01	6.5007E-01	1.5906E-01	1.5926E-01	5.0902E-02	4.6200E-01	7.2558E-01	7.2558E-01	7.2558E-01	
>>> LATERAL/DEFECTONAL STABILITY <<<												
REAL	IMAGINARY	T F/L-SEC	1/T H/D	PERIOD-SEC	DNATE-CPS	UNDNAT-CFS	DAMP RATIO	DECAY RATIO				
-8.6656E-01	+ 5.2873E-01	7.9593E-01	1.25C2E-01	1.1844E-01	8.5272E-01	8.6149E-01	1.6174E-01	1.4857E-01	3.5708E-01	3.5708E-01	3.5708E-01	
-1.1545E-01	+ 9.6654E-01	6.0000E-01	1.6656E-01	6.5007E-01	1.5492E-01	1.5583E-01	1.1860E-01	1.1627E-01	4.7214E-01	4.7214E-01	4.7214E-01	
-1.1730E-01	+ 1.1133E-01	5.9093E-01	1.6922E-01	5.6537E-01	1.7687E-01	1.7786E-01	1.0496E-01	9.5675E-01	5.1522E-01	5.1522E-01	5.1522E-01	

ET. ATT. TENSIONE CABLE TENSION

```

TENSIA = 2.042 DEC
TENSIA = -1.65 DEC
FRE.CAE. TENSIONE = C.19CE27E-03 IES
RF.CAE. TENSIONE = C.182037E-03 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D-SEC
-6.7627E-01 +-6.2738E-03 1.6267E-01 1.7565E-01 PERIOD-SEC
-4.9429E-01 +-1.0261E-01 1.4023E-01 7.1311E-01 1.0020E-00 9.9P03E-01 UNDNAT-CPS
-1.1746E-00 +-9.9972E-02 6.0453E-01 1.6542E-00 6.1235E-01 1.63331E-00 1.0722E-01 9.7759E-01
-1.1746E-00 +-1.1369E-01 6.0453E-01 1.6939E-00 5.5267E-01 1.6350E-00 4.8117E-02 7.3884E-01

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$$APC(94) = 196.00$$

ET. ATT. DEFLIN. & CABLE TENSION

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TENSIA = 2.042 DEC
TENSIA = -1.61 DEC
FRE.CAE. TENSIONE = C.202213E-03 IES
RF.CAE. TENSIONE = C.195EC37E-03 IES
>>> LONGITUDINAL STABILITY <<<
REAL IMAGINARY T H/D-SEC
-6.7627E-01 +-6.3623E-03 1.7562E-01 9.8759E-01 PERIOD-SEC
-4.9429E-01 +-1.0523E-01 1.4045E-01 6.9421E-01 1.0126E-01 1.0185E-00 1.0764E-01 UNDNAT-CPS
-1.1746E-00 +-1.1623E-01 6.0456E-01 1.6456E-00 6.2068E-01 1.6764E-00 4.5683E-02 4.1453E-01

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>>> LATEROAL/DIRECTONAL STABILITY <<<

REAL IMAGINARY T H/D-SEC

-8.7019E-01 +-5.4256E-01 1.2684E-01 1.1581E-00 PERIOD-SEC

-4.8616E-01 +-1.0123E-01 1.6767E-01 1.6456E-00 8.6351E-01 6.7478E-01 UNDNAT-CPS

-1.1607E-00 +-1.1619E-01 1.6922E-01 1.6943E-00 1.6111E-00 1.6213E-00 1.5996E-01 1.4689E-00

-1.1746E-00 +-1.1746E-01 1.6922E-01 1.6943E-00 1.6493E-00 1.8587E-00 1.0056E-01 9.1618E-01

DECAY RATIO 5.2951E-01

CASE(= 3 FIRST DATA CHANGE CL AND CM ALPHA
FOR CABLE VERTICAL,EAR CABLE HORIZONTAL
AC SNUBBERS

NC LIFT/ANTI-LIFT CABLE

DATA CHANGE
S ECCCC
5 -1.3010
0 0.0

EF. ATT. DEFINING CABLE TENSION

THEIA = 2.94 DEC

LEIA = -2.7E DEC

PFT CAP. TENS. ICH = 0.120742E 03 IFS
RS CAP. TENS. ICH = C.14CC53E C3 IBS

>>> INSTITUTIONAL STABILITY <<<

REAL IMAGINARY T H/D- SEC 1/T H/D PERIOD-SEC UNDANT-CPS DNAME-CP5 DAMP RATIO DECAY RATIO
-3.56C5E-C1 +4.5501E 00 5.7138E-01 1.3809E 00 7.2418E-01 8.6714E-01 7.69CCE-01 5.7874E-01
-6.5065E-01 +9.9917E 00 1.0104E 00 5.8197E-C1 6.2EE4E-C1 1.5902E 00 1.59339E 00 6.7965E-02 6.1750E-01 6.51ECE-C1

CASE 4 TEST DATA FOR HORIZONTAL NO SNUBBERS

AC LIFT/ANTI-LIFT CASE

S	6.2200
E	-C.87CC
7.0	C.0
7.4	3.5.030
8.1	2E.46C
8.7	8.4000
9.1	C.87CC
C	(.)

END AT DEFINITION CASE TENSION

THETA = 2.51 EEC

DELTA = -2.12 DEG

END CASE TENSION = C.12ECE C1 IES

RP CASE TENSION = 0.140039E 03 IES

>>> LONGITUDINAL STABILITY <<<

2541 INTEGRAL STABILITY <<<

-2.9E7SE-C1 +-5.5731E 00 2.3517E 00 4.2E23E-C1 1/T E/E

-6.6118E-C1 +-6.0CE1E CC 1.C4E4E CC 5.5388E-C1

>>> INTERNAL/EXTERNAL STABILITY <<<

REAL STABILITY <<<

-1.7863E 00 +-2.7C53E CC 3.8E11E-C1 2.5766E 00

-1.433SE CC +-7.2526E 00 4.8352E-C1 2.0682E 00

-5.185SE-C1 +-9.7303E 00 1.3366E 00 7.4816E-C1

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

PERIOD SEC 1/T E/E

-1.7941E-01 5.2815E-02 4.7941E-01

-7.1727E-01 7.4841E-01 8.2284E-02

5.9526E-C1 7.4841E-01

APPENDIX D

Contained in this Appendix is a program listing. The subroutines as they appear in the listing are itemized below:

EXEC ROUTINE
SUBROUTINE RUTLOC
SUBROUTINE TRANS
SUBROUTINE TRAN1
SUBROUTINE LATSN
SUBROUTINE TRIM
SUBROUTINE EQU
SUBROUTINE FPLYV
SUBROUTINE RPLYH
SUBROUTINE DLGTH
SUBROUTINE DCOSLG
SUBROUTINE LONG
SUBROUTINE PRINTR
SUBROUTINE MASH
SUBROUTINE LAT
SUBROUTINE DCOSD
SUBROUTINE SNTRM
SUBROUTINE LONGSN
SUBROUTINE DRCSN
SUBROUTINE DRCUSN
SUBROUTINE RITE
SUBROUTINE STINT
SUBROUTINE TABIN
SUBROUTINE STINT1
SUBROUTINE TABIN1
SUBROUTINE FRICT
SUBROUTINE FRVT
SUBROUTINE FRHZ
SUBROUTINE MATRIX
SUBROUTINE POLADD
SUBROUTINE POLSUB
SUBROUTINE POLMPY
SUBROUTINE MATMPY
SUBROUTINE TRACE
SUBROUTINE COMPBI

APPENDIX D (CONT.)

SUBROUTINE ENVERT
SUBROUTINE SCALER
SUBROUTINE EQUIL
SUBROUTINE PRBML
SUBROUTINE PQFB1
SUBROUTINE ENVERT
SUBROUTINE SCALER
SUBROUTINE EQUIL
SUBROUTINE PRBML
SUBROUTINE PQFB1

C EXEC ROUTINE BEGINS HERE

COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
 COMMON /SNUBR/SNU(3,3),SN(30),THUSN,THLSP,SNUC(3,3)
 COMMON ZZZ(200)
 COMMON /TAB1/ZZ(ECC)
 COMMON /DU/DLM(10,10)
 DIMENSION TITLE(20),SAVE(50),SAVE1(150)
 EQUIVALENCE(AERO(1), CDU),(AERO(2), CLL),(AERO(3), CMU),
 1 (AERO(4), CDA),(AERO(5), CLA),(AERO(6), CMA),
 2 (AERO(7), CDQ),(AERO(8), CLG),(AERO(9), CMQ),
 3 (AERO(10), CDO),(AERO(11), CLC),(AERO(12), CMQ),
 4 (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
 5 (AERO(16), CDAD),(AERO(17), CLAC),(AERO(18), CMAD),
 6 (AERO(19), CYB),(AERO(20), CLE),(AERO(21), CNB),
 7 (AERO(22), CYP),(AERO(23), CLF),(AERO(24), CNP),
 8 (AERO(25), CYR),(AERO(26), CLF),(AERO(27), CNR),
 9 (AERO(28), CYDR),(AERO(29), CLCF),(AERO(30), CNDR),
 A (AERO(31), CYDA),(AERO(32), CLCA),(AERO(33), CNDA),
 B (AFRO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS),
 C (AERO(44), XREF),(AERO(45), ZFEF),(AERO(46), XCG),
 D (AERO(47), ZCG)
 EQUIVALENCE(AERO(48),AMACH),(AERO(49),VC),(AERC(50), AM)
 EQUIVALENCE(AERO(51),RHO),(AERO(52), WT),(AERO(53), B)
 EQUIVALENCE(AFRO(54),CBAR),(AERO(55),SH),(AERC(56), XIXZ)
 EQUIVALENCE(AERO(57),XIXX),(AERO(58),YIYY),(AERC(59),ZIZZ)
 EQUIVALENCE(AERO(60),CLT),(AERO(61),CCT),(AERC(62),CMT),
 1 (AERO(63),THE TA)
 EQUIVALENCE(AERO(66),WLUF),(AERO(67), WLLF),(AERC(68), WLUR),
 1 (AERO(69), WLLR),(AERO(70), WLHF),(AERC(71), WLHR),
 2 (AERO(72), STAF),(AERO(73), STAR),(AERC(74), BLHF),
 3 (AERO(75), BLHR),(AERO(76), WLCR),(AERC(77), STACR),
 4 (AERO(78), BLCR),(AERC(79), EF),(AERC(80), ER),
 5 (AERO(81), AF),(AERO(82), AR),(AERC(83), HUCF),
 6 (AERO(84), HLCF),(AERO(85), HLCR),(AERO(86), HLCR),
 7 (AERO(87), DCF),(AERO(88), CCF),
 8 (AERO(90), RVF),(AERO(91), FHF),(AERC(92), RVR),
 9 (AERO(93), RHR),(AERO(94), TFO),(AERO(95), AKR),
 A (AERO(96), COU),(AERC(97), STLTT),(AERC(98), WLLTT),
 B (AERO(99), TLFTO),(AERO(100), AKLFT),
 C (AERO(102), ALTX),(AERO(103), ALT2),(AERC(104), CMP)
 EQUIVALENCE(AERO(105), SNLX),(AERO(106), SNUY),(AERC(107), SNUZ),
 1 (AERO(108), SNLX),(AERO(109), SNY),(AERC(110), SNLZ),
 2 (AERO(111), SNUST),(AERO(112), SNLWL),(AERO(113), SNUBL),
 3 (AERO(114), SNLST),(AERO(115), SNLWL),(AERO(116), SNLBL),
 4 (AERO(117), TUSNO),(AERO(118), TLSNE),(AERO(119), AKSNU),
 5 (AERO(120), AKSNL),(AERO(121), ACSNU),(AERC(122), ACSNL),
 6 (AERO(123), AKSY),(AERO(124), AKPHI),(AERO(125), AKTHE),
 7 (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128), T2PHI),
 8 (AERO(129), T3THE),(AERC(130), T4AZ)
 EQUIVALENCE(AEROP(1), CXUP),(AEROP(2), CZLF),(AERC(3), CMUP),
 1 (AEROP(4), CXAP),(AEROP(5), CZAF),(AEROP(6), CMAP),
 2 (AEROP(7), CXQP),(AEROP(8), CZCF),(AERC(9), CMQP),
 3 (AEROP(10), CXOP),(AEROP(11), CZCF),(AERC(12), CMOP),
 4 (AEROP(13), CXDEP),(AERC(14), CZDEF),(AERC(15), CMDEP),
 5 (AEROP(16), CXADP),(AEROP(17), CZADP),(AERC(18), CMADP), CBL 00010
 CBL 00020
 CBL 00030
 CBL 00040
 CBL 00050
 CBL 00060
 CBL 00070
 CBL 00080
 CBL 00090
 CBL 00100
 CBL 00110
 CBL 00120
 CBL 00130
 CBL 00140
 CBL 00150
 CBL 00160
 CBL 00170
 CBL 00180
 CBL 00190
 CBL 00200
 CBL 00210
 CBL 00220
 CBL 00230
 CBL 00240
 CBL 00250
 CBL 00260
 CBL 00270
 CBL 00280
 CBL 00290
 CBL 00300
 CBL 00310
 CBL 00320
 CBL 00330
 CBL 00340
 CBL 00350
 CBL 00360
 CBL 00370
 CBL 00380
 CBL 00390
 CBL 00400
 CBL 00410
 CBL 00420
 CBL 00430
 CBL 00440
 CBL 00450
 CBL 00460
 CBL 00470
 CBL 00480
 CBL 00490
 CBL 00500
 CBL 00510
 CBL 00520
 CBL 00530
 CBL 00540
 CBL 00550

FILE CABLE FORTRAN P1

G E L M A N D A T A S Y S T E M S

6 (AEROP(19), CYBP), (AEROP(20), CLEF), (AEROP(21), CNBP), CBL 00560
7 (AEROP(22), CYPP), (AEROP(23), CLFF), (AEROP(24), CNPP), CBL 00570
8 (AEROP(25), CYRP), (AEROP(26), CLFP), (AEROP(27), CNRP), CBL 00580
9 (AEROP(28), CYDRP), (AEROP(29), CLDRP), (AEROP(30), CNDRP), CBL 00590
A (AEROP(31), CYDAP), (AEROP(32), CLCAF), (AEROP(33), CNCAP), CBL 00600
B (AEROP(34), CYDSP), (AEROP(35), CLCSF), (AERCP(36), CNDSP) CBL 00610
EQUIVALENCE (SN(1), GX1), (SN(2), GY1), (SN(3), GZ1), CBL 00620
1 (SN(4), GX2), (SN(5), GY2), (SN(6), GZ2), CBL 00630
2 (SN(7), GX3), (SN(8), GY3), (SN(9), GZ3), CBL 00640
3 (SN(10), GX4), (SN(11), GY4), (SN(12), GZ4), CBL 00650
4 (SN(13), THU), (SN(14), THL), (SN(15), ALU), CBL 00660
5 (SN(16), ALL), CBL 00670
6 (SN(19), THGX1), (SN(20), THGY1), (SN(21), THGZ1), CBL 00680
7 (SN(22), THGX2), (SN(23), THGY2), (SN(24), THGZ2), CBL 00690
8 (SN(25), THGX3), (SN(26), THGY3), (SN(27), THGZ3), CBL 00700
9 (SN(28), THGX4), (SN(29), THGY4), (SN(30), THGZ4) CBL 00710
KASE=0 CBL 00720
IR=5 CBL 00730
IW=6 CBL 00740
LL=0 CBL 00750
DO 11 J=1,EC CBL 00760
11 SAVE(J)=9999. CBL 00770
LL=0 CBL 00780
READ(IR,15C)(TITLE(I),I=1,20) CBL 00790
READ(IR,20C)(KODE(I),I=1,16) CBL 00800
200 FORMAT(16I5) CBL 00810
WRITE(IW,17C) KODE(1),(TITLE(I),I=1,20) CBL 00820
1 FORMAT(1H1.3X,*CASE NO=*,I3.4X,20A4) CBL 00830
CALL RITE CBL 00840
IF(KODE(7).EQ.1) GO TO 10 CBL 00850
READ(IR,10C)(AERO(I),I=1,36) CBL 00860
GO TO 20 CBL 00870
10 CALL TABIN(1,36,NG) CBL 00880
IF(NG.EQ.0) GO TO 20 CBL 00890
WRITE(IW,3C0) NG CBL 00900
300 FORMAT(//,* ERROR IN READING TABLES 1-36,NG=*,I2) CBL 00910
GO TO 500 CBL 00920
20 READ(IR,10C)(AERO(I),I=44,59) CBL 00930
READ(IR,100)(AERO(I),I=66,130) CBL 00940
100 FORMAT(6E12.5) CBL 00950
IF(KODE(12).NE.-1) GO TO 32 CBL 00960
CALL TABIN(1,2,NG) CBL 00970
IF(NG.EQ.0) GO TO 32 CBL 00980
WRITE(IW,420) NG CBL 00990
420 FORMAT(* ERROR IN READING SNUBBER DATA TABLE,NG=*,I3) CBL 01000
GO TO 500 CBL 01010
1000 DO 2E I=1,150 CBL 01020
28 AERO(I)=SAVE1(I) CBL 01030
READ(IR,15C)(TITLE(I),I=1,20) CBL 01040
150 FORMAT(20A4) CBL 01050
KASE=1 CBL 01060
DO 34 J=1,EC CBL 01070
34 SAVE(J)=9999. CBL 01080
READ(IR,20C)(KODE(I),I=1,16) CBL 01090
WRITE(IW,17C) KODE(1),(TITLE(I),I=1,20) CBL 01100

```

CALL RITE                               CBL01110
WRITE(IW,3E2)                           CBL01120
31 FORMAT(3X,'DATA CHANGE')
26 READ(IR,3EC) K,VALUE                CBL01130
350 FORMAT(I3,E12.E)                   CBL01140
WRITE(IW,3E1)K,VALUE                  CBL01150
351 FORMAT(3X,I3,3X,G12.5)
IF(K.LT.1) GO TO 22                   CBL01160
AERO(K)=VALUE                         CBL01170
IF(K.LT.37) SAVE(K)=AERO(K)           CBL01180
GO TO 26                                CBL01190
22 LL=0                                 CBL01200
32 IF(KODE(7).EQ.0) GO TO 31           CBL01210
DO 30 I=1,36                            CBL01220
CALL STINT1(AMACH,0,0,I,I,AERC(I),NG) CBL01230
IF(NG.NE.0) GO TO 40                   CBL01240
30 CONTINUE                             CBL01250
DO 36 J=1,36                            CBL01260
36 IF(SAVE(J).NE.9999.) AERO(J)=SAVE(J) CBL01270
GO TO 31                                CBL01280
40 WRITE(IW,4CC) I,NG                  CBL01290
400 FORMAT(//,*' ERROR IN TABLE NO*',I4,*'NG='*,I3)
GO TO 500                               CBL01300
360 FORMAT(EE10.3)                      CBL01310
31 IF(KASE.EQ.1) GO TO 9               CBL01320
WRITE(IW,EC1)                           CBL01330
801 FORMAT(5X,'INPUT DATA AS SPECIFIED IN AEFC ARRAY')
WRITE(IW,8C0)(I,AERO(I),I=1,130)       CBL01340
808 FORMAT(5(2X,'AERO(*,I3,*)=*',G10.3))
9 DO 25 I=1,150                          CBL01350
25 SAVE1(I)=AERO(I)
IF(KODE(3).EQ.0) GO TO 48              CBL01360
42 DO 27 I=1,150                          CBL01370
27 AERO(I)=SAVE1(I)
CALL RUTLOC                            CBL01380
IF(LL.EQ.0) GO TO 1000                 CBL01390
48 CALL TRAN1                           CBL01400
IF(KODE(5).EQ.0) GO TO 49              CBL01410
WRITE(IW,EC2)
802 FORMAT(4X,'AERO DATA IN STAB. AXIS AT EGLAT. FEF. CENTER')
WRITE(IW,EC0)(I,AERO(I),I=1,36)       CBL01420
49 CALL TRIM                           CBL01430
CALL TRANS                            CBL01440
IF(KODE(5).EQ.0) GO TO 50              CBL01450
WRITE(IW,EC3)
803 FORMAT(4X,'AERO DATA IN BCDY AXIS AT EGLAT. FEF. CENTER')
WRITE(IW,EC4)(I,AEROP(I),I=1,36)      CBL01460
804 FORMAT(5(2X,'AEROP(*,I3,*)=*',G10.3))
50 IF(KODE(2)) 70,EC,90                CBL01470
70 WRITE(IW,7CC)
700 FORMAT('* +---+ LONGITUDINAL STABILITY +---+')
CALL LONG                             CBL01480
IF(KODE(3).EQ.1) GO TO 42              CBL01490
GO TO 1000
80 WRITE(IW,7EC)

```

FILE CABLE FORTRAN P1

G F U N K M A N D A T A S Y S T E M S

```
750 FORMAT(' +++++ LATERAL/DIRECTIONAL STABILITY +++++')          CBL 01660
      CALL LAT                                              CBL 01670
      IF(KODE(3).EQ.1) GO TO 42                               CBL 01680
      GO TO 1000                                            CBL 01690
  90 WRITE(IW,700)
      CALL LONG
      WRITE(IW,750)
      CALL LAT
      IF(KODE(3).EQ.1) GO TO 42                               CBL 01710-
      GO TO 1000
500 STOP
END
SUBROUTINE RUTLOC
COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
IW=6
IF(LL.GT.0) GO TO 42
II=KODE(4)
VARY= ABS(AERO(II)*.1)
ANOM= AERO(II)
L=0
LL=1
WRITE(IW,600) II
600 FORMAT( 1H1,3X,* ROOT LOCUS VARYING AERC(*,I3,*) )
 42 L=L+1
II=KODE(4)
AERO(II)=ANOM-E.*VARY+L*VARY
IF(L.GT.5) GO TO 44
WRITE(IW,1E0) KODE(4),AERO(II)
150 FORMAT(/2X,5HAERO(,I3,2H)=,G12.5)
RETURN
 44 AERO(II)=ANOM
LL=0
RETURN
END
SUBROUTINE TRANS
C THIS ROUTINE CALCULATES BODY AXIS AERO DATA AT CR FROM STAB.
C AXIS AERO DATA AT CR
COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL
EQUIVALENCE(AERO( 1), CDU),(AERO( 2), CLL),(AERO( 3), CMU),
 1      (AERO( 4), CDA),(AERO( 5), CLA),(AERC( 6), CMA),
 2      (AERO( 7), CDQ),(AERO( 8), CLG),(AERO( 9), CMQ),
 3      (AERO(10), CDO),(AERO(11), CLC),(AERO(12), CMQ),
 4      (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
 5      (AERO(16), CDAD),(AERO(17), CLAC),(AERC(18), CMAD),
 6      (AERO(19), CYB),(AERO(20), CLE),(AERO(21), CNB),
 7      (AERO(22), CYP),(AERO(23), CLF),(AERO(24), CNP),
 8      (AERO(25), CYR),(AERO(26), CLF),(AERC(27), CNR),
 9      (AERO(28), CYDR),(AERO(29), CLCF),(AERO(30), CNDR),
A      (AERO(31), CYDA),(AERO(32), CLCA),(AERO(33), CNDA),
B      (AERO(34), CYDS),(AERO(35), CLCS),(AERO(36), CNDS),
C      (AERO(44), XREF),(AERO(45), ZFEF),(AERC(46), XCG),
D      (AERO(47), ZCG),(AERO(63), THETA)
EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUF),(AEROP( 3), CMUP),
 1      (AEROP( 4), CXAP),(AEROP( 5), CZAF),(AEROP( 6), CMAP),
 2      (AEROP( 7), CXQP),(AEROP( 8), CZGF),(AEROP( 9), CMQP), CBL 02180
CBL 02190
CBL 02200
```

FILE CABLE FORTRAN P1

G F U N N A R D A T A S Y S T E M S

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3      (AEROP(10), CXOP), (AEROP(11), C2(F)), (AEROP(12), CMOP), CBL 02210
4      (AEROP(13), CXDEP), (AEROP(14), C2DEF), (AERCP(15), CMDEP), CBL 02220
5      (AEROP(16), CXADP), (AEROP(17), C2AEF), (AERCP(18), CMADP), CBL 02230
6      (AEROP(19), CYBP), (AEROP(20), CLEF), (AERCP(21), CNBP), CBL 02240
7      (AEROP(22), CYPP), (AEROP(23), CLFF), (AERCP(24), CNPP), CBL 02250
8      (AEROP(25), CYRP), (AEROP(26), CLR), (AEROP(27), CNRP), CBL 02260
9      (AEROP(28), CYDRP), (AEROP(29), CLDRP), (AERCP(30), CNDRP), CBL 02270
A      (AEROP(31), CYDAP), (AEROP(32), CLDAP), (AERCP(33), CNDAP), CBL 02280
B      (AEROP(34), CYDSP), (AEROP(35), CLDSP), (AEROP(36), CNDSP) CBL 02290
IW=6
ALPHA=THETA
SNALF= SIN(ALPHA)
COALF= COS(ALPHA)
SN SQ = SNALF**2
CO SQ = COALF**2
SN CO = SNALF*COALF
CDU=CDU+2.* (CDO+CDA* THE TA )
CLU=CLU+2.* (CLD+CLA* THE TA )
CDA=CDA-(CLD+CLA* THE TA )
CLA=CLA+CDO+CDA*THE TA
CX UP=-CLA*SN SQ-CDU*CO SQ+(CDA+CLU)*SNCC
CZ UP= CDA*SN SQ-CLU*CO SQ+(CLA-CDU)*SNCO
CM UP= -CMA *SNALF+ CMU *COALF
CX AP= CLU*SN SQ-CDA*CO SQ+(CLA-CDU)*SNCC
CZ AP= -CDL*SN SQ-CLA*CO SQ-(CDA+CLU)*SNCO
CM AP= CMU *SNALF+ CMA *COALF
CX QP= CLQ*SNALF-CDQ*COALF
CZ QP=-(CDQ*SNALF+CLQ*COALF)
CM QP= CMQ
CZ ADP=-CLAD*COALF+CDAD* SNALF
CX ADP=-CDAD*COALF-CLAD* SNALF
CM ADP= CMAD
CX DEP= CLDE*SNALF-CDDE*COALF
CZ DEP=-CDDE*SNALF-CLDE*COALF
CM DEP= CMDE
CY BP= CYB
CN BP= CLB *SNALF+ CNB *COALF
CL RP= -CNB *SNALF+ CLB *COALF
CY PP= (-CYR*SNALF+ CYP*COALF)
CN PP=(-CLR*SN SQ+ CNP*CO SQ+ (CLP- CNF)*SNCC)
CL PP=( CNR*SN SQ+ CLP*CO SQ- (CLR+ CNF)*SNCC)
CY RP= ( CYP*SNALF+ CYR*COALF)
CN RP=( CLP*SN SQ+ CNR*CO SQ+ (CLR+ CNF)*SNCC)
CL RP=(-CNP*SN SQ+ CLR*CO SQ+ (CLP- CNF)*SNCC)
CY DAP= CYDA
CN DAP= CLDA*SNALF+ CNDA*COALF
CL DAP= -CNDA*SNALF+ CLDA*COALF
CY DRP= CYDR
CN DRP= CLDR*SNALF+ CNDR*COALF
CL DRP=-CNDR*SNALF+ CLDR*COALF
CY DSP= CYDS
CL DSP=-CNDS*SNALF+ CLDS*COALF
CN DSP= CLDS*SNALF+ CNDS*COALF
RETURN
END

```

FILE CABLE FORTRAN P1

G R U N K A N D A T A S Y S T E M S

SUBROUTINE TRAN1

C THIS ROUTINE TRANSFORMS INERTIA DATA & STABILITY AXIS AERO DATA
C THE EQUATION REFERENCE CENTER

COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL

1 EQUIVALENCE(AERO(1), CDU),(AERO(2), CLU),(AERO(3), CMU),
2 (AERO(4), CDA),(AERO(5), CLA),(AERO(6), CMA),
3 (AERO(7), CDQ),(AERO(8), CLQ),(AERO(9), CNQ),
4 (AERO(10), CDO),(AERO(11), CLC),(AERO(12), CMO),
5 (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CNDE),
6 (AERO(16), CDAD),(AERO(17), CLAC),(AERO(18), CMAC),
7 (AERO(19), CYB),(AERO(20), CLE),(AERO(21), CNB),
8 (AERO(22), CYP),(AERO(23), CLF),(AERO(24), CNP),
9 (AERO(25), CYR),(AERO(26), CLF),(AERO(27), CNR),
A (AERO(28), CYDR),(AERO(29), CLF),(AERO(30), CNDR),
B (AERO(31), CYDA),(AERO(32), CLCA),(AERO(33), CNDA),
C (AERO(34), CYDS),(AERO(35), CLCS),(AERO(36), CNDS),
D (AERO(44), XREF),(AERO(45), ZREF),(AERO(46), XCG),
E (AERO(47), ZCG),(AERO(63), THETA)

EQUIVALENCE(AERO(48),AMACH),(AERO(49),VC),(AERO(50), AM)
EQUIVALENCE(AERO(51),RHO),(AERO(52), WT),(AERO(53),B)
EQUIVALENCE(AERO(54),CBAR),(AERO(55),SV),(AERO(56), XIXZ)
EQUIVALENCE(AERO(57),XIXX),(AERO(58),YIYY),(AERO(59),ZIZZ)
EQUIVALENCE(AERO(60),CLT),(AERO(61),CDT),(AERO(62),CMT)

C INERTIA TRANSFORMATIONS

X=XCC/12.
Z=ZCC/12.
XIXX=XIXX+AM*(Z**2)
YIYY=YIYY+AM*(X**2)+AM*(Z**2)
ZIZZ=ZIZZ+AM*(X**2)
XIXZ=XIXZ-AM*X*Z

C AERO DATA TRANSFORMATIONS

X=XREF/(12.*CBAR)
Z=ZREF/(12.*CBAR)
CMO=CMO-Z*CDO+X*CLD
CMA=CMA-Z*CDA+X*CLA
CMQ=CMQ-Z*CDQ+X*CLQ
CMDE=CMDE-Z*CDDE+X*CLDE
X=XCG/(12.*B)
Z=ZCG/(12.*B)
CNB=CNB+X*CYR
CNR=CNR+X*CYR
CNP=CNP+X*CYP
CNDR=CNDR+X*CYDR
CNDA=CNDA+X*CYDA
CNDS=CNDS+X*CYDS
CLR=CLR-Z*CYB
CLR=CLR-Z*CYR
CLP=CLP-Z*CYP
CLDR=CLDR-Z*CYDR
CLDA=CLDA-Z*CYDA
CLDS=CLDS-Z*CYDS
RETURN
END

SUBROUTINE LATSN

COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL

CBL 02760
CBL 02770
CBL 02780
CBL 02790
CBL 02800
CBL 02810
CBL 02820
CBL 02830
CBL 02840
CBL 02850
CBL 02860
CBL 02870
CBL 02880
CBL 02890
CBL 02900
CBL 02910
CBL 02920
CBL 02930
CBL 02940
CBL 02950
CBL 02960
CBL 02970
CBL 02980
CBL 02990
CBL 03000
CBL 03010
CBL 03020
CBL 03030
CBL 03040
CBL 03050
CBL 03060
CBL 03070
CBL 03080
CBL 03090
CBL 03100
CBL 03110
CBL 03120
CBL 03130
CBL 03140
CBL 03150
CBL 03160
CBL 03170
CBL 03180
CBL 03190
CBL 03200
CBL 03210
CBL 03220
CBL 03230
CBL 03240
CBL 03250
CBL 03260
CBL 03270
CBL 03280
CBL 03290
CBL 03300

FILE CABLE F FORTRAN P1

G R U N D A N D A T A S Y S T E M S

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COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSR,SNLD(3,3)          CBL 03310
COMMON ZZZ(200)                                              CBL 03320
COMMON/DU/DUM(10,10)                                         CBL 03330
COMMON/TAB1/ZZ(EOO)                                         CBL 03340
EQUIVALENCE(AERO(105), SNLX),(AERO(106), SNLY),(AERO(107), SNLZ), CBL 03350
1(AERO(108), SNLX),(AERO(109), SNLY),(AEFC(110), SNLZ),    CBL 03360
2(AERO(111), SNLST),(AERO(112), SNLWL),(AEFC(113), SNLBL), CBL 03370
3(AERO(114), SNLST),(AERO(115), SNLWL),(AEFC(116), SNLBL), CBL 03380
4(AERO(117), TUSNO),(AERO(118), TLSNO),(AEFC(119), AKSNU), CBL 03390
5(AERO(120), AKSNL),(AERO(49), VO),(AEFC(51), FHC),        CBL 03400
6(AERO(63), THETA),(AERO(121), ADSNU),(AEFC(122), ACSNL)   CBL 03410
EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1),      CBL 03420
1(SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2),                CBL 03430
2(SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3),                CBL 03440
3(SN(10), GX4),(SN(11), GY4),(SN(12), GZ4),                CBL 03450
4(SN(13), THU),(SN(14), THL),(SN(15), ALL),                CBL 03460
5(SN(16), ALL).                                             CBL 03470
6(SN(19), THGX1),(SN(20), THGY1),(SN(21), THGZ1),          CBL 03480
7(SN(22), THGX2),(SN(23), THGY2),(SN(24), THGZ2),          CBL 03490
8(SN(25), THGX3),(SN(26), THGY3),(SN(27), THGZ3),          CBL 03500
9(SN(28), THGX4),(SN(29), THGY4),(SN(30), THGZ4)           CBL 03510
DIMENSION TOPR(3,3),TOPL(3,3),BOTR(3,3),ECTL(3,3)          CBL 03520
COT(BBB)=1./TAN(BBB)                                         CBL 03530
GY(A,AA,C)          = (-A*CCT(AA)/C)*12.                  CBL 03540
GSY(A,AA,C,D,E,F) = -(A*SIN(AA)+C*D*CCT(E))/F            CBL 03550
GPHI(A,AA,C,D,E,F,G) = (A*AA*COT(C)-C*D*CCT(F))/G       CBL 03560
GYY(A,AA)          = (SIN(A)/AA)*12.                         CBL 03570
GSY(A,AA,C,D,E,F) = (A*AA*COT(C)+D*SIN(E))/F            CBL 03580
GPHI(A,AA,C,D,E,F) = -(A*SIN(AA)+C*D*CCT(E))/F          CBL 03590
GZY(A,AA,C)          = (-A*CCT(AA)/C)*12.                  CBL 03600
GSY(A,AA,C,D,E,F,G) = (A*AA*COT(C)-D*E*CCT(F))/G       CBL 03610
GPHI(A,AA,C,D,E,F) = (A*AA*COT(C)+C*SIN(E))/F            CBL 03620
ALY(A)              = -A                                     CBL 03630
ALSY(A,AA,C,D)     = (A*AA-C*D)/12.                         CBL 03640
ALPHI(A,AA,C,D)    = (A*AA-C*D)/12.                         CBL 03650
IW=6
DO 1005 I=1,3
DO 1006 J=1,3
SNU(I,J)=0
1005 SNUD(I,J)=0
DO 1006 I=1,10
DO 1006 J=1,10
1006 DUM(I,J)=0
IF(KODE(10).EQ.0) GO TO 1002
C TERMS FOR SNUBBER EFFECTS (LAT)
CALL DRCSN(THETA)
IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
DUM(1,2) = -TUSNO*GX1
DUM(1,3) = TLSNO*GZ1
DUM(1,5) = -TUSNO*SIN(THGY1)
DUM(1,7) = GY1
DUM(2,2) = SNLX*TUSNO*GX1/12.+SNUY*TUSNC*GY1/12.
DUM(2,3) = -SNLX*TUSNO*GZ1/12.
DUM(2,4) = -SNLY*TUSNO*SIN(THGX1)/12.
DUM(2,5) = SNLX*TUSNU*SIN(THGY1)/12.

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FILE CABLE FORTRAN P1

G F U N P A R DATA S Y S T E M S

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DUM(2,7) = (-SNUX*GY1+SNY*GX1)/12.          CBL 03860
DUM(3,2) = -SNUZ*TUSNO*GX1/12.                CBL 03870
DUM(3,3) = SNUZ*TUSNO*GZ1/12.+SNLY*TUSNC*GY1/12. CBL 03880
DUM(3,5) = -SNUZ*TUSNO*SIN(THGY1)/12.          CBL 03890
DUM(3,6) = SNLY*TUSNO*SIN(THGZ1)/12.            CBL 03900
DUM(3,7) = (-SNUY*GZ1+SNUZ*GY1)/12.            CBL 03910
DUM(4,1) = GXY(GY1,THGX1,ALL)                  CBL 03920
DUM(4,2) = GXSY(-SNUY,THGX1,-SNUX,GY1,THGX1,ALU) CBL 03930
DUM(4,3) = GXPHI(-SNUZ,GY1,THGX1,-SNUY,GZ1,THGX1,ALU) CBL 03940
DUM(4,4) = -1.                                  CBL 03950
DUM(5,1) = GYY(THGY1,ALL)                      CBL 03960
DUM(5,2) = GYSY(-SNUY,GX1,THGY1,-SNUX,THGY1,ALU) CBL 03970
DUM(5,3) = GYPHI(-SNUZ,THGY1,-SNUY,GZ1,THGY1,ALU) CBL 03980
DUM(5,5) = -1.                                  CBL 03990
DUM(6,1) = GZY(GY1,THGZ1,ALL)                  CBL 04000
DUM(6,2) = GZSY(-SNUY,GX1,THGZ1,-SNUX,GY1,THGZ1,ALU) CBL 04010
DUM(6,3) = GZPHI(-SNUZ,GY1,THGZ1,-SNUY,THGZ1,ALU) CBL 04020
DUM(6,6) = -1.                                  CBL 04030
IF(KODE(10).EQ.2) GO TO 1010
CALL DRC SN(THE TA)
Q=.5*RHO*VO*VO
ALU1=ALU+1.
CALL STINT(Q,ALL1,0,1,1,TUSN1,NG)             CBL 04080
IF(NG.NE.0) GO TO 5000
ALU2=ALU-1.
CALL STINT(Q,ALU2,0,1,1,TLEN2,NG)             CBL 04110
IF(NG.NE.0) GO TO 5000
GO TO 5001
5000 WRITE(IW,5C02) NG,ALL,ALU,G              CBL 04140
5002 FORMAT(*ERROR IN SNUBBER TABLE 1,NG=*,I2,3>E10.3) CBL 04150
RETURN
5001 CONTINUE
AK TU=(TUSN1-TUSN2)/2.
AK SNU=AK TU
CBL 04180
1010 CONTINUE
DUM(7,7) = -1.                                CBL 04210
DUM(7,8) = AKSNU*12.                            CBL 04220
DUM(8,1) = ALY(GY1)                            CBL 04230
DUM(8,2) = ALSY(-SNUY,GX1,-SNUX,GY1)          CBL 04240
DUM(8,3) = ALPHI(-SNUZ,GY1,-SNUY,GZ1)         CBL 04250
DUM(8,8) = -1.                                  CBL 04260
IF(KODE(10).EQ.1) GO TO 1015
DO 1016 I=1,3
DO 1016 J=1,3
1016 SVUD(I,J)=DUM(I,7)*ADSNU*DUM(8,J)*12.
1015 CALL MASH(3,8)
DO 1050 I=1,3
DO 1050 J=1,3
1050 TOPR(I,J)= DUM(I,J)
IF(KODE(10).EQ.1) CALL DRC USN(THE TA)
DUM(1,2) = -TUSNO*GX2                         CBL 04360
DUM(1,3) = TUSNO*GZ1                           CBL 04370
DUM(1,5) = -TUSNO*SIN(THGY2)                   CBL 04380
DUM(1,7) = GY2                                 CBL 04390
DUM(2,2) = SNUX*TUSNO*GX2/12.-SNLY*TUSNC*GY2/12. CBL 04400

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FILE CABLE FORTRAN P1

G F U N K A N D A T A S Y S T E M S

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DUM( 2, 3) = -SNUX*TUSNO*GZ2/12.          CBL 04410
DUM( 2, 4) = SNUY*TUSNO*SIN(THGX2)/12.      CBL 04420
DUM( 2, 5) = SNLX*TUSNO*SIN(THGY2)/12.      CBL 04430
DUM( 2, 7) = (-SNUX*GY2-SNLY*GX2)/12.       CBL 04440
DUM( 3, 2) = -SNLZ*TUSNO*GX2/12.            CBL 04450
DUM( 3, 3) = SNUZ*TUSNO*GZ2/12.-SNUY*TUSN(GY2/12. CBL 04460
DUM( 3, 5) = -SNLZ*TUSNO*SIN(THGY2)/12.      CBL 04470
DUM( 3, 6) = -SNLY*TUSNO*SIN(THGZ2)/12.      CBL 04480
DUM( 3, 7) = (SNUY*GZ2+SNLZ*GY2)/12.        CBL 04490
DUM( 4, 1) = GXY(GY2,THGX2,ALL)             CBL 04500
DUM( 4, 2) = GXSy(SNUY,THGX2,-SNUX,GY2,THGX2,ALU) CBL 04510
DUM( 4, 3) = GXPHI(-SNUZ,GY2,THGX2,SNUY,GZ2,THGX2,ALU) CBL 04520
DUM( 4, 4) = -1.                            CBL 04530
DUM( 5, 1) = GYY(THGY2,ALU)                CBL 04540
DUM( 5, 2) = GYSy(SNUY,GX2,THGY2,-SNUX,THEY2,ALU) CBL 04550
DUM( 5, 3) = GYPHI(-SNUZ,THGY2,SNUY,GZ2,THGY2,ALU) CBL 04560
DUM( 5, 5) = -1.                            CBL 04570
DUM( 6, 1) = GZY(GY2,THGZ2,ALL)             CBL 04580
DUM( 6, 2) = GZSy(SNUY,GX2,THGZ2,-SNUX,GY2,THGZ2,ALU) CBL 04590
DUM( 6, 3) = GZPHI(-SNUZ,GY2,THGZ2,SNUY,THGZ2,ALU) CBL 04600
DUM( 6, 6) = -1.                            CBL 04610
IF(KODE( 10).EQ.2) GO TO 1C20              CBL 04620
CALL DRCSEN(THE TA)                      CBL 04630
ALU1=ALU+1.                                CBL 04640
CALL STINT(Q,ALU1,0,1,1,TUSN1,NG)          CBL 04650
IF(NG.NE.0) GO TO 5000                    CBL 04660
ALU2=ALU-1.                                CBL 04670
CALL STINT(Q,ALU2,0,1,1,TUSN2,NG)          CBL 04680
IF(NG.NE.0) GO TO 5000                    CBL 04690
AK TU=(TUSN1-TUSN2)/2.                     CBL 04700
AK SNU=AK TU                                CBL 04710
1020 CONTINUE                                CBL 04720
DUM( 7, 7) = -1.                            CBL 04730
DUM( 7, 8) = AK SNU*12.                     CBL 04740
DUM( 8, 1) = ALY(GY2)                       CBL 04750
DUM( 8, 2) = ALSy(SNUY,GX2,-SNLX,GY2)      CBL 04760
DUM( 8, 3) = ALPHI(-SNUZ,GY2,SNUY,GZ2)     CBL 04770
DUM( 8, 8) = -1.                            CBL 04780
IF(KODE( 10).EQ.1) GO TO 1C25              CBL 04790
DO 1C26 I=1,3                                CBL 04800
DO 1C26 J=1,3                                CBL 04810
1026 SNUD(I,J)=SNUD(I,J)+DUM(I,7)*ADSNU*DUM(8,J)*12. CBL 04820
1025 CALL MASH( 3,8)                          CBL 04830
DO 1C60 I=1,3                                CBL 04840
DO 1060 J=1,3                                CBL 04850
1060 TOPL(I,J)=DUM(I,J)                      CBL 04860
IF(KODE( 10).EQ.1) CALL DRCSEN(THE TA)      CBL 04870
DUM( 1, 2) = -TLSNO*GX3                     CBL 04880
DUM( 1, 3) = TLSNO*GZ3                      CBL 04890
DUM( 1, 5) = -TLSNO*SIN(THGY3)               CBL 04900
DUM( 1, 7) = GY3                            CBL 04910
DUM( 2, 2) = SNLX*TLSNO*GX3/12.-SNLY*TLSN(GY3/12. CBL 04920
DUM( 2, 3) = -SNLX*TLSNO*GZ3/12.            CBL 04930
DUM( 2, 4) = SNLY*TLSNO*SIN(THGX3)/12.      CBL 04940
DUM( 2, 5) = SNLX*TLSNO*SIN(THGY3)/12.      CBL 04950

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FILE CABLE FORTRAN P1

G R U N D A N DATA SYSTEMS

DUM(2, 7) = (- SNLX*GY3-SNLY*GX3)/12. CBL 04960
DUM(3, 2) = SNLZ*TLSNO*GX3/12. CBL 04970
DJM(3, 3) = - SNLZ*TLSNO*GZ3/12.-SNLY*TLSNC*GY3/12. CBL 04980
DUM(3, 5) = SNLZ*TLSNO*SIN(THGY3)/12. CBL 04990
DUM(3, 6) = - SNLY*TLSNO*SIN(THGZ3)/12. CBL 05000
DUM(3, 7) = (SNLY*GZ3-SNLZ*GY3)/12. CBL 05010
DUM(4, 1) = GXY(GY3,THGX3,ALL) CBL 05020
DUM(4, 2) = GXSy(SNLY,THGX3,-SNLX,GY3+THGX3,ALL) CBL 05030
DUM(4, 3) = GXPHI(SNLZ,GY3,THGX3,SNLY,GZ3,THGZ3,ALL) CBL 05040
DUM(4, 4) = -1. CBL 05050
DUM(5, 1) = GYY(THGY3,ALL) CBL 05060
DUM(5, 2) = GYSy(SNLY,GX3,THGY3,-SNLX,THGY3,ALL) CBL 05070
DUM(5, 3) = GYPHI(SNLZ,THGY3,SNLY,GZ3,THGY3,ALL) CBL 05080
DUM(5, 5) = -1. CBL 05090
DUM(6, 1) = GZY(GY3,THGZ3,ALL) CBL 05100
DUM(6, 2) = GZSy(SNLY,GX3,THGZ3,-SNLX,GY3,THGZ3,ALL) CBL 05110
DUM(6, 3) = GZPHI(SNLZ,GY3,THGZ3,SNLY,THGZ3,ALL) CBL 05120
DUM(6, 6) = -1. CBL 05130
IF(KODE(10).EQ.2) GO TO 1030 CBL 05140
CALL DRCsn(THETA) CBL 05150
ALL1=ALL+1. CBL 05160
CALL STINT(Q,ALL1,0,1,1,TLsn1,NG) CBL 05170
IF(NG.NE.0) GO TO 5000 CBL 05180
ALL2=ALL-1. CBL 05190
CALL STINT(Q,ALL2,0,1,1,TLsn2,NG) CBL 05200
IF(NG.NE.0) GO TO 5000 CBL 05210
AKTL=(TLsn1-TLsn2)/2. CBL 05220
AKSNL=AKTL CBL 05230
1030 CONTINUE CBL 05240
DUM(7, 7) = -1. CBL 05250
DUM(7, 8) = AKSNL*12. CBL 05260
DUM(8, 1) = ALY(GY3) CBL 05270
DUM(8, 2) = ALSy(SNLY,GX3,-SNLX,GY3) CBL 05280
DJM(8, 3) = ALPHI(SNLZ,GY3,SNLY,GZ3) CBL 05290
DUM(8, 8) = -1. CBL 05300
IF(KODE(10).EQ.1) GO TO 1035 CBL 05310
DO 1036 I=1,3 CBL 05320
DO 1036 J=1,3 CBL 05330
1036 SNUd(I,J)=SNUd(I,J)+DUM(I,7)*ADSNL*DUM(E..)*12. CBL 05340
1035 CALL MASH(3, 8) CBL 05350
DO 1070 I=1,3 CBL 05360
DO 1070 J=1,3 CBL 05370
1070 BOTL(I,J)=DUM(I,J) CBL 05380
IF(KODE(10).EQ.1) CALL DRCusn(THETA) CBL 05390
DUM(1, 2) = - TLSNO*GX4 CBL 05400
DUM(1, 3) = TLSNO*GZ4 CBL 05410
DUM(1, 5) = - TLSNO*SIN(THGY4) CBL 05420
DUM(1, 7) = GY4 CBL 05430
DUM(2, 2) = SNLX*TLSNO*GX4/12.+SNLY*TLSNC*GY4/12. CBL 05440
DUM(2, 3) = - SNLX*TLSNO*GZ4/12. CBL 05450
DUM(2, 4) = - SNLY*TLSNO*SIN(THGX4)/12. CBL 05460
DUM(2, 5) = SNLX*TLSNO*SIN(THGY4)/12. CBL 05470
DUM(2, 7) = (- SNLX*GY3+SNLY*GX4)/12. CBL 05480
DUM(3, 2) = SNLZ*TLSNO*GX4/12. CBL 05490
DUM(3, 3) = - SNLZ*TLSNO*GZ4/12.+SNLY*TLSNC*GY4/12. CBL 05500

FILE CABLE FORTRAN PI

G F L M P A N DATA SYSTEMS

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DUM( 3, 5) = SNLZ*TL SNO*SIN( THGY4)/12.          CBL 05510
DUM( 3, 6) = SNLY*TL SNO*SIN( THGZ4)/12.          CBL 05520
DUM( 3, 7) = (-SNLY*GZ4-SNLZ*GY4)/12.            CBL 05530
DUM( 4, 1) = GXY(GY4,THGX4,ALL)                   CBL 05540
DUM( 4, 2) = GXSY(-SNLY,THGX4,-SNLX,GY4,THGX4,ALL) CBL 05550
DUM( 4, 3) = GXPHI(SNLZ,GY4,THGX4,-SNLY,GZ4,THGY4,ALL) CBL 05560
DUM( 4, 4) = -1.                                    CBL 05570
DUM( 5, 1) = GYY(THGY4,ALL)                      CBL 05580
DUM( 5, 2) = GYSY(-SNLY,GX4,THGY4,-SNLX,THGY4,ALL) CBL 05590
DUM( 5, 3) = GYPHI(SNLZ,THGY4,-SNLY,GZ4,THGY4,ALL) CBL 05600
DUM( 5, 5) = -1.                                    CBL 05610
DUM( 6, 1) = GZY(GY4,THGZ4,ALL)                   CBL 05620
DUM( 6, 2) = GZSY(-SNLY,GX4,THGZ4,-SNLX,GY4,THGZ4,ALL) CBL 05630
DUM( 6, 3) = GZPHI(SNLZ,GY4,THGZ4,-SNLY,THGZ4,ALL) CBL 05640
DUM( 6, 6) = -1.                                    CBL 05650
IF(KODE( 10).EQ.2) GO TO 1040
CALL DRCSN( THETA)
ALL1=ALL+1.
CALL STINT(Q,ALL1,C,1,1,TL SN1,NG)               CBL 05660
IF(NG.NE.0) GO TO 5000
ALL2=ALL-1.
CALL STINT(Q,ALL2,0,1,1,TL SN2,NG)               CBL 05670
IF(NG.NE.C) GO TO 5000
AKTL=(TL SN1-TL SN2)/2.
AK SNL=AK TL
C3NT INUE
1040 DUM( 7, 7) = -1.                            CBL 05680
DUM( 7, 8) = AKSNL*12.                          CBL 05690
DUM( 8, 1) = ALY(GY4)                           CBL 05700
DUM( 8, 2) = ALSY(-SNLY,GX4,-SNLX,GY4)         CBL 05710
DUM( 8, 3) = ALPHI(SNLZ,GY4,-SNLY,GZ4)          CBL 05720
DUM( 8, 8) = -1.                                CBL 05730
IF(KODE( 10).EQ.1) GO TO 1045
DO 1046 I=1,3
DO 1046 J=1,3
1046 SNUD( I,J)=SNUD( I,J)+DUM( I,7)*ADSNL*DLM( 8,.)*12.
1045 CALL MASH( 3,8)
DO 1080 I=1,3
DO 1080 J=1,3
1080 BCTR( I,J)= DUM( I,J)
DO 1090 I=1,3
DO 1090 J=1,3
1090 SNU( I,J)= TOPR( I,J)+TOPL( I,J)+BCTL( I,J)+ECTR( I,J)
IF(KODE( 10).EQ.2) RETURN
DO 1095 I=1,3
DO 1095 J=1,3
1095 SNUD( I,J)=C
RETURN
1002 DO 1004 I=1,3
DO 1004 J=1,3
SNUD( I,J)=C
1004 SNU( I,J)=0
RETURN
END
SUBROUTINE TRIM

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FILE CABLE FORTRAN P1

G F U N K M A N D A T A S Y S T E M S

C CABLE SUSPENSION SYSTEM TRIM RCLTINE CBL06060
 COMMON /DAT/ AERO(150),AEROP(50),KCDE(2C),LL CBL06070
 COMMON /PLYCHA/R TD,XLGTH(5),ADC(5,3),AFN(5,3),TR,TLFT,TF CBL06080
 DIMENSION ANG(5,3) CBL06090
 EQUIVALENCE(AERO(1), CDU),(AERO(2), CLL),(AERO(3), CMU), CBL06100
 1 (AERO(4), CDA),(AERO(5), CLA),(AERO(6), CMA), CBL06110
 2 (AERO(7), CDQ),(AERO(8), CLC),(AERC(9), CMQ), CBL06120
 3 (AERO(10), CDO),(AERO(11), CLC),(AERO(12), CMQ), CBL06130
 4 (AERO(13), CDDE),(AERO(14), CLDE),(AERC(15), CMDE), CBL06140
 5 (AERO(16), CDAD),(AERO(17), CLAD),(AERC(18), CMAD), CBL06150
 6 (AERO(19), CYB),(AERO(20), CLE),(AERO(21), CNB), CBL06160
 7 (AERO(22), CYP),(AERO(23), CLF),(AERO(24), CNP), CBL06170
 8 (AERO(25), CYR),(AERO(26), CLF),(AERC(27), CNR), CBL06180
 9 (AERO(28), CYDR),(AERO(29), CLCF),(AERC(30), CNDR), CBL06190
 A (AERO(31), CYDA),(AERO(32), CLCA),(AERO(33), CNDA), CBL06200
 B (AERO(34), CYDS),(AERO(35), CLCS),(AERC(36), CNDS) CBL06210
 EQUIVALENCE(AERO(46), XCG),(AERC(47), ZCG) CBL06220
 EQUIVALENCE(AERO(48), AMACH),(AERO(49), VC),(AERO(50), AM) CBL06230
 EQUIVALENCE(AERO(51), RH0),(AERO(52), WT),(AERC(53), B) CBL06240
 EQUIVALENCE(AERO(54), CBAR),(AERO(55), SV),(AERC(56), XIXZ) CBL06250
 EQUIVALENCE(AERO(57), XIXX),(AERO(58), YIYY),(AERO(59), ZIZZ) CBL06260
 EQUIVALENCE(AERO(60), CLT),(AERO(61), CET),(AERC(62), CMT), CBL06270
 1(AERO(63), THETA) CBL06280
 EQUIVALENCE(AERO(66), WLLF),(AERO(67), WLLF),(AERC(68), WLUR), CBL06290
 1 (AERO(69), WLLR),(AERO(70), WLHF),(AERC(71), WLHR), CBL06300
 2 (AERO(72), STAF),(AERO(73), STAR),(AERC(74), BLHF), CBL06310
 3 (AERO(75), BLHR),(AERO(76), HLCF),(AERC(77), STACR), CBL06320
 4 (AERO(78), BLCR),(AERO(79), EF),(AERC(80), ER), CBL06330
 5 (AERO(81), AF),(AERO(82), AR),(AERO(83), HUCF), CBL06340
 6 (AERO(84), HLCF),(AERO(85), HLCF),(AERC(86), HLCR), CBL06350
 7 (AERO(87), DCF),(AERO(88), ECA),(AERC(89), ALF), CBL06360
 8 (AERO(90), RVF),(AERO(91), FHF),(AERC(92), RVR), CBL06370
 9 (AERO(93), RHR),(AERO(94), TFO),(AERC(95), AKF), CBL06380
 A (AERO(96), ALRC),(AERO(97), STLTT),(AERC(98), WLLTT), CBL06390
 B (AERO(99), TLFT0),(AERO(100), AKLFT),(AERO(101), ALLTO), CBL06400
 C (AERO(102), ALTX),(AERO(103), ALT2) CBL06410
 EQUIVALENCE(AEROP(1), CXLP),(AEROP(2), CZLF),(AERC(3), CMUP), CBL06420
 1 (AEROP(4), CXAP),(AEROP(5), CZAF),(AEROP(6), CMAP), CBL06430
 2 (AEROP(7), CXQP),(AEROP(8), CZCF),(AERC(9), CMQP), CBL06440
 3 (AEROP(10), CXOP),(AEROP(11), CZCF),(AEROP(12), CMOP), CBL06450
 4 (AEROP(13), CXDEP),(AEROP(14), CZDEF),(AERC(15), CMDEP), CBL06460
 5 (AFROP(16), CXADP),(AEROP(17), CZADF),(AERC(18), CMADP), CBL06470
 6 (AEROP(19), CYBP),(AEROP(20), CLEF),(AERC(21), CNBP), CBL06480
 7 (AEROP(22), CYPP),(AEROP(23), CLFF),(AERC(24), CNPP), CBL06490
 8 (AEROP(25), CYRP),(AEROP(26), CLFF),(AERC(27), CNRP), CBL06500
 9 (AEROP(28), CYDRP),(AEROP(29), CLEFF),(AERC(30), CNDRP), CBL06510
 A (AEROP(31), CYDAP),(AEROP(32), CLCAF),(AERO(33), CNDAP), CBL06520
 B (AEROP(34), CYDSP),(AEROP(35), CLCSF),(AERC(36), CNDSP) CBL06530
 RTD=57.295E
 THETA=C.
 DELALF=.001
 DTF=.1
 DALFAW=0.0
 DDEL TE=0.0
 DTFRST=0.0
 CBL06540
 CBL06550
 CBL06560
 CBL06570
 CBL06580
 CBL06590
 CBL06600

FILE CABLE FORTRAN P1

G R U N D A N D A S Y S T E M S

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ICNTR=0                                CBL 06610
FIRST=C.                                CBL 06620
THINT=C.                                CBL 06630
ALFINT=THETA                            CBL 06640
DELINT=0.                                CBL 06650
THRSTO=THINT                            CBL 06660
ALFAW0=ALFINT                           CBL 06670
DELTE0=DELINT                           CBL 06680
QS=RHO*VO*VO*.E*SW                     CBL 06690
209 THRSTI=THRSTO+DTHRST               CBL 06700
ALFAWI=ALFAW0+DALFAW                   CBL 06710
DELTEI=DELTE0+DDELTE                   CBL 06720
ICNTR=ICNTR+1                           CBL 06730
IF( ICNTR .GT. 10C)GO TO 520           CBL 06740
VAL1=ALFAWI*R TD                       CBL 06750
VAL2=DELTEI*R TD                       CBL 06760
VAL3=THRSTI                            CBL 06770
CALL EQU(ALFAWI,DELTEI,THRSTI,F0,G0,HC,FIRST)
IF(FIRST.NE.1.)FIRST=1.
C COMPUTES PARTIALS
ALFAWI=ALFAWI+DELALF*0.5              CBL 06800
CALL EQU(ALFAWI,DELTEI,THRSTI,F1,G1,H1,1.)
A_FAWI=ALFAWI-DELALF                  CBL 06810
CALL EQU(ALFAWI,DELTEI,THRSTI,F2,G2,H2,1.)
ALFAWI=ALFAWI+DELALF*0.5              CBL 06820
FALFW0=(F1-F2)/DELALF                 CBL 06830
GALFW0=(G1-G2)/DELALF                 CBL 06840
HALFW0=(H1-H2)/DELALF                 CBL 06850
FDELE0=-QS*(CLDE*COS(ALFAWI)+CDDE*SIN(ALFAWI)) CBL 06860
GDELE0=QS*(CLDE*SIN(ALFAWI)-CDDE*COS(ALFAWI)) CBL 06870
HDELE0=QS*CBAR*CMDE                  CBL 06880
THRSTI=THRSTI+DTF                     CBL 06890
CALL EQU(ALFAWI,DELTEI,THRSTI,F1,G1,H1,1.)
THRSTI=THRSTI-2.*DTF                 CBL 06900
CALL EQU(ALFAWI,DELTEI,THRSTI,F2,G2,H2,1.)
THRSTI=THRSTI+DTF                     CBL 06910
FTHSTO=(F1-F2)/DTF                   CBL 06920
GTHSTO=(G1-G2)/DTF                   CBL 06930
HTHSTO=(H1-H2)/DTF                   CBL 06940
C SET UP ITERATION EQUATIONS
FI=F0+FALFW0*DALFAW+FDELE0*DDELTE+FTHSTC*ETHRST CBL 06950
GI=G0+GALFW0*DALFAW+GDELE0*DDELTE+GTHSTC*ETHRST CBL 06960
HI=H0+HALFW0*DALFAW+HDELE0*DDELTE+HTHSTC*ETHRST CBL 06970
ACCZ=FI/AM                            CBL 06980
ACCX=GI/AM                            CBL 06990
THEDOT=HI/YIYY                         CBL 07000
IF(ABS(ACCZ).LT..01)GO TO 1005        CBL 07010
GO TO 1100                            CBL 07020
1005 IF(ABS(ACCX).LT..01)GO TO 1007    CBL 07030
GO TO 1100                            CBL 07040
1007 IF(ABS(THEDOT).LE.0.001)GO TO 42   CBL 07050
C NOW COMPUTE PARAMETER INCREMENTS FROM MATRIX EQUATIONS
1100 DETRM=FALFW0*GDELE0*HTHSTO+FDELE0*GTHSTC*HALFW0+FTHST0*GALFW0* CBL 07060
1HDELE0-FTHST0*GDELE0*HALFW0-FALFW0*GTHSTC*HCELEC-FDELE0*GALFW0* CBL 07070
2HTHSTO                                         CBL 07080

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FILE CABLE FORTRAN PI

G R U P P A N D A T A S Y S T E M S

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DALFAW=(-(GDELEO*HTHSTO-GTHSTO*HDELEO)*FC+(FDELEO*HTHSTO-FTHSTO
1*HDELEO)*GO-(FDELEO*GTHSTO-FTHSTO*GDELEO)*HC)/DETRM CBL 07160
DDELTE=(+(GALFWO*HTHSTO-GTHSTO*HALFWC)*FC-(FALFWC*HTHSTO-HALFWO
1*FTHSTO)*GO+(FALFWO*GTHSTO-FTHSTO*GALFWC)*HC)/DETRM CBL 07180
DTFRST=(-(GALFWO*HDELEO-GDELEO*HALFWO)*FC+(FALFWC*HCELEO-FDELEO
1*HALFWO)*GO-(FALFWO*GDELEO-FDELEO*GALFWC)*HC)/DETRM CBL 07190
THRSTI=THRSTI CBL 07200
ALFAWI=ALFAWI CBL 07210
DELTEI=DELTEI CBL 07220
GO TO 209 CBL 07230
520 WRITE(6,521) CBL 07240
521 FORMAT(" TRIM ITERATION EXCEEDS LIMITS") CBL 07250
GO TO 522 CBL 07260
42 CALL EQU(ALFAWI,DELTEI,THRSTI,FC,GC,HC,1.) CBL 07270
522 DO 523 IZZ=1,4 CBL 07280
DO 523 IZK=1,3 CBL 07290
ANG(IZZ,IZK)=ADC(IZZ,IZK)*RTD CBL 07300
523 CONTINUE CBL 07310
THETA=ALFAWI CBL 07320
DE=DELTEI CBL 07330
TF=THRSTI CBL 07340
THETC=THETA*R TD CBL 07350
DED=DE*R TD CBL 07360
DO 524 IZZ=1,4 CBL 07370
IF(KODE(5).EQ.0) GO TO 526 CBL 07380
525 WRITE(6,525)IZZ,XLGH(IZZ),(ANG(IZZ,IZK),AFN(IZZ,IZK),IZK=1,3) CBL 07390
FORMAT(" CABLE GEOMETRY-CABLE NO.",IZZ," CABLE LENGTH=",E15.6,
1" IN",/,3X," DIR. COS.=DEG ARM-IN",/,3(3X,2E15.6,/))//)
526 FORMAT(" ITERATION PARAMETER =",I5,/,2X,"ACCZ =",E15.8,
1/,2X,"ACCX =",E15.8,/,2X,"THEDGT =",E15.8," RAD/SEC") CBL 07400
527 WRITE(6,527)THETD,DED,TF,TR CBL 07410
FORMAT(//,"VEH. ATT.,DEFLTN,& CABLE TENSION",/,
12X,"THETA =",F6.2," DEG",/,2X,"DELTA =",F6.2," DEG",/,2X
2,"FRT CAB. TENSION =",E15.6," LBS",/,2X
32X,"RR CAB. TENSION =",E15.6," LBS")
RETURN
END
SUBROUTINE EQU(THETA,DE,TF,FF,GG,HH,FIRST)
      CABLE SUSPENSION SYSTEM TRIM EQUATIONS
COMMON /DAT/ AERO(150),AEROP(50),KCDE(2C),LL
COMMON /PLYCHA/RTD,XLGH(5),ADC(5,3),AFN(5,3),TR,TLFT,DUMMY
REAL*8 XNM1,XNM2,YNM1,YNM2
EQUIVALENCE(AERO( 1), CDL),(AERO( 2), CLL),(AERC( 3), CMU),
1 (AERO( 4), CDA),(AERO( 5), CLA),(AERC( 6), CMA),
2 (AERO( 7), CDQ),(AERO( 8), CLC),(AERC( 9), CMQ),
3 (AERO(10), CDO),(AERO(11), CLC),(AERO(12), CMQ),
4 (AERO(13), CDDE),(AERO(14), CLCE),(AERO(15), CMDE),
5 (AERO(16), CDAD),(AERO(17), CLAC),(AERC(18), CMAD),
6 (AERO(19), CYB),(AERO(20), CLE),(AERO(21), CNB),
7 (AERO(22), CYP),(AERO(23), CLF),(AERO(24), CNP),
8 (AERO(25), CYR),(AERO(26), CLF),(AERC(27), CNR),
9 (AERO(28), CYDR),(AERO(29), CLEF),(AERO(30), CNDR),
A (AERO(31), CYDA),(AERO(32), CLEA),(AERO(33), CNDA).

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FILE CABLE FORTRAN PI

G R U N D A R D A T A S Y S T E M S

B	(AERO(34), CYDS), (AERO(35), CLCS), (AERO(36), CNDS)	CBL 07710
	EQUIVALENCE(AERO(46), XCG), (AERO(47), ZCG)	CBL 07720
	EQUIVALENCE(AERO(48), AMACH), (AERO(49), VC), (AERC(50), AM)	CBL 07730
	EQUIVALENCE(AERO(51), RHO), (AERO(52), WT), (AERC(53), B)	CBL 07740
	EQUIVALENCE(AERO(54), CBAR), (AERO(55), SV), (AERO(56), XIIZ)	CBL 07750
	EQUIVALENCE(AERO(57), XIXX), (AERO(58), YIYY), (AERC(59), ZIZZ)	CBL 07760
	EQUIVALENCE(AERO(60), CLT), (AERO(61), CCT), (AERO(62), CMT)	CBL 07770
	EQUIVALENCE(AERO(66), WLUF), (AERO(67), WLLF), (AERC(68), WLUR),	CBL 07780
I	(AERO(69), WLLR), (AERO(70), WLHF), (AERC(71), WLHR),	CBL 07790
2	(AERO(72), STAF), (AERO(73), STAR), (AERC(74), BLHF),	CBL 07800
3	(AERO(75), BLHR), (AERO(76), WLCF), (AERC(77), STACR),	CBL 07810
4	(AERO(78), BLCR), (AERO(79), EF), (AERC(80), ER),	CBL 07820
5	(AERO(81), AF), (AERO(82), FR), (AERO(83), HUCF),	CBL 07830
6	(AERO(84), HLCF), (AERO(85), HLCF), (AERC(86), HLCR),	CBL 07840
7	(AERO(87), DCF), (AERO(88), CC), (AERC(89), ALF),	CBL 07850
8	(AERO(90), RVF), (AERO(91), FHF), (AERO(92), RVR),	CBL 07860
9	(AERO(93), RHR), (AERO(94), TF), (AERC(95), AKR),	CBL 07870
A	(AERO(96), ALR), (AERO(97), STLTT), (AERO(98), WLLTT),	CBL 07880
B	(AERO(99), TLFTC), (AERO(100), AKLFT), (AERO(101), ALLT),	CBL 07890
C	(AERO(102), ALTX), (AERO(103), ALT2)	CBL 07900
	DATA XNM1, XNM2 /"VERTICAL", "HORIZONTAL"/	CBL 07910
	RTD=57.295E	CBL 07920
	VAL1=THETA	CBL 07930
	Q = RHO*VO*VD/2.0	CBL 07940
64	IND=KODE(6)	CBL 07950
	GO TO (5C1,502,5C3,504),IND	CBL 07960
501	YNM1=XNM1	CBL 07970
	YNM2=XNM2	CBL 07980
	CALL FPLYV(STAF,WLUF,WLLF,HUCF,HLCF,EF,FVF,THETA,1)	CBL 07990
	CALL RPLYH(STAR,BLHR,WLHR,-AR,DCR,0.,RHF,THETA,3)	CBL 08000
	GO TO 505	CBL 08010
502	YNM1=XNM2	CBL 08020
	YNM2=XNM1	CBL 08030
	CALL RPLYH(STAF,BLHF,WLHF,AF,DCF,0.,RHF,THETA,1)	CBL 08040
	CALL FPLYV(STAR,WLUR,WLLR,HUCR,HLCR,ER,FVF,THETA,3)	CBL 08050
	GO TO 505	CBL 08060
503	YNM1=XNM1	CBL 08070
	YNM2=XNM1	CBL 08080
	CALL FPLYV(STAF,WLUF,WLLF,HUCF,HLCF,EF,FVF,THETA,1)	CBL 08090
	CALL FPLYV(STAR,WLUR,WLLR,HUCR,HLCR,ER,FVF,THETA,3)	CBL 08100
	GO TO 505	CBL 08110
504	YNM1=XNM2	CBL 08120
	YNM2=XNM2	CBL 08130
	CALL RPLYH(STAF,BLHF,WLHF,AF,DCF,0.,RHF,THETA,1)	CBL 08140
	CALL RPLYH(STAR,BLHR,WLHR,-AR,DCR,0.,RHF,THETA,3)	CBL 08150
505	IF(KODE(1))5C6,5C7,5C6	CBL 08160
506	WLLT = WLCR + ALTX*SIN(THETA) - ALTZ*CCS(THETA)	CBL 08170
	STALT = STACR - ALTX*COS(THETA) - ALTZ*SIN(THETA)	CBL 08180
	XLGTH(5) = SQRT((WLLTT - WLLT)**2 + (STLTT - STALT)**2)	CBL 08190
	IF(FIRST.NE.0.)GO TO 12	CBL 08200
	ELL0=XLGTH(5)	CBL 08210
12	FLL=XLGTH(5)	CBL 08220
	T_FT = TLFTC+AKLFT*(ELL-ELL0)	CBL 08230
	ARM(5,1)=ALTX	CBL 08240
	ARM(5,2)=C	CBL 08250

FILE CABLE FOR TRAN P1

G F U N K A R D A T A S Y S T E M S

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ARM(5,3)=ALTZ                                CBL 08260
FXLTT = (TLFT*(STALT - STLTT))/XLGTH(5)      CBL 08270
FZLTT = (TLFT*(WLLT - WLLTT))/XLGTH(5)      CBL 08280
FXLTB = FXLTT*COS(THETA) - FZLTT*SIN(THETA)  CBL 08290
FZLTB = FZLTT*COS(THETA) + FXLTT*SIN(THETA)  CBL 08300
YMLFT =( FXLTB*ALTZ - FZLTB*ALTX)/12.          CBL 08310
ADC(5,1)=ARCOS(FXLTB/TLFT)                  CBL 08320
ADC(5,2)=3.14159/2.                          CBL 08330
ADC(5,3)=ARCOS(FZLTB/TLFT)                  CBL 08340
GO TO 50E                                    CBL 08350
507 FXLTB=0.                                 CBL 08360
FZLTB=C.                                    CBL 08370
YMLFT=0.                                    CBL 08380
TLFT=0                                     CBL 08390
XLGTH(5)=0.                                 CBL 08400
DO 13 IA=1,3                                CBL 08410
ARM(5,IA)=0.                                 CBL 08420
ADC(5,IA)=C.                                CBL 08430
13 CONTINUE                                CBL 08440
508 CALL SNTRM(FXSN,FZSN,EMEN,THETA)        CBL 08450
IF (FIRST.NE.0.)GO TO 510                  CBL 08460
IF(KODE(5).EQ.C) GO TO 512                CBL 08470
WRITE(6,509)YNM1,YNM2                      CBL 08480
509 FORMAT(' CABLE CONFIGURATION CN MODEL'//,
  ' FRONT CABLE IS ',A8,' AND REAR CABLE IS ',A8) CBL 08490
512 EL 0=XLGTH(3)+XLGTH(4)                CBL 08500
510 EL =XLGTH(3)+XLGTH(4)                CBL 08510
TR=TRO+AKR*(EL-EL 0)                      CBL 08520
TR=TR+AKR*(EL-EL 0)                      CBL 08530
EL IFT=Q*SW*(CLO+CLA*THE TA+CLDE*DE)    CBL 08540
ADRAM=Q*SW*(CDO+CDA*THE TA+CDDE*DE)    CBL 08550
FXAIR=-ADRAM*COS(THE TA)+ELIFT*SIN(THE TA) CBL 08560
FZAIR=-ADRAM*SIN(THE TA)-ELIFT*COS(THE TA) CBL 08570
WGTX=-32.2*AM*SIN(THE TA)                 CBL 08580
WGTZ=32.2*AM*COS(THE TA)                 CBL 08590
EMWGT=(ZCG*WGTX-XCG*WGTZ)/12.            CBL 08600
FXCR=TR*(COS(ADC(3,1))+COS(ADC(4,1)))  CBL 08610
FZCR=TR*(COS(ADC(3,3))+COS(ADC(4,3)))  CBL 08620
FXCFH=TF*(COS(ADC(1,1))+COS(ADC(2,1))) CBL 08630
FZCFH=TF*(COS(ADC(1,3))+COS(ADC(2,3))) CBL 08640
EMOC=0.                                     CBL 08650
DO 511 I=1,4                                CBL 08660
TENS=TF                                    CBL 08670
IF(I.GT.2)TENS=TR                          CBL 08680
FMOC=EMOC+TFNS*(COS(ADC(1,1))*ARM(1,3)-COS(ADC(1,3))*ARM(1,1)) CBL 08690
511 CONTINUE                                CBL 08700
EMOC=EMOC/12.                              CBL 08710
AEROM=Q*SW*CBAR*(CMO+CMA*THE TA+CMDE*DE) CBL 08720
FF=FZCFH+FZCR+FZLTB+FZSN+WGTZ+FZAIR   CBL 08730
GG=FXCFH+FXCR+FXLTB+FXSN+WGTX+FXAIR   CBL 08740
HH=EMOC+YMLFT+EMSN+EMWGT+AEROM          CBL 08750
RETURN                                     CBL 08760
END                                         CBL 08770
SUBROUTINE FPL(YV(STAV,WLU,WLL,HHU,HHL,EF,FAC,THETA,IF)
COMMON /DAT/AERO(150),AEROP(5C),KODE(20),LL
COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF CBL 08780
                                         CBL 08790
                                         CBL 08800

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FILE CABLE FORTRAN P1

G F L N P A N DATA SYSTEMS

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EQUIVALENCE (AERO(76),WLCR),(AERO(77),STACR),(AERO(78),BLCR)      CBL 08810
PI=3.14159
GAMU= ATAN(HHL/EP)
T1= EP*EP +HHU*HHU
T2= THETA +GAMU
IF( IF.EQ.3) T2=GAMU-THETA
WLUC= WLCR +SQRT(T1)*SIN(T2)
T3= WLU -WLUC
T4= ABS(STACR -STAV) -SQRT(T1)*COS(T2)
XLUP= SQRT(T3*T3+T4*T4)
XLU= SQRT(XLUP*XLUP -RAD*RAD)
BUP= ATAN(T3/T4)
DBU= ATAN(RAD/XLL)
BETAU=(BUP -DBU)*RTD
GAML= ATAN(HHL/EP)
T5= EP*EP +HHL*HHL
T6= THETA -GAML
IF( IF.EQ.3) TE=- (THETA+GAML)
WLLC= WLCR +SQRT(T5)*SIN(T6)
T7= WLLC -WLL
T8= ABS(STACR -STAV) -SQRT(T5)*COS(T6)
XLLP= SQRT(T7*T7 +T8*T8)
XLL= SQRT(XLLP*XLLP -RAD*RAD)
BLP= ATAN(T7/TE)
DBL= ATAN(RAD/XLL)
BETAL= (BLP -DBL)*RTD
IF( IF.EQ.1)GO TO 1
XLGTH(3)=XLU
XLGTH(4)=XLL
ADC(3,1)=BETAU/RTD- THETA+PI
ADC(3,2)=-PI/2.
ADC(3,3)=PI/2.-ADC(3,1)
ADC(4,1)=PI-(BETAL/RTD- THETA)
ADC(4,2)=-PI/2
ADC(4,3)=PI/2-ADC(4,1)
ARM(3,1)=-FP+RAD*SIN(ADC(3,1))
ARM(3,2)=0.
ARM(3,3)=-FHU+RAD*COS(ADC(3,1))
ARM(4,1)=-FP-RAD*SIN(ADC(4,1))
ARM(4,2)=0.
ARM(4,3)=HHL-RAD*COS(ADC(4,1))
RETURN
I XLGTH(1)=XLL
XLGTH(2)=XLL
ADC(1,1)=-BETAL/RTD+THETA
ADC(1,2)=PI/2.
ADC(1,3)=PI/2.-ADC(1,1)
ADC(2,1)=BETAL/RTD+THETA
ADC(2,2)=PI/2.
ADC(2,3)=PI/2.-ADC(2,1)
ARM(1,1)=EP+RAD*SIN(ADC(1,1))
ARM(1,2)=0.
ARM(1,3)=-FHU-RAD*COS(ADC(1,1))
ARM(2,1)=EP-RAD*SIN(ADC(2,1))
ARM(2,2)=C.

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FILE CABLE FORTRAN P1

G F U P P A N D A T A S Y S T E M S

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ARM( 2, 3)=HHL+RAD*COS(ADC( 2,1))
RETURN
END
SUBROUTINE RPLYH(STAD,BLD,WLD,XP,YP,ZP,FAC,THETA,IF)
COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),AFH(5,3),TR,TLFT,TF
EQUIVALENCE(AERO(76),WLCR),(AERO(77),STACF),(AEFC(78),BLCR)
PI=3.14159
XWT=STACR-STAD
ZWT=WLCR-WLD
XB=XWT*COS( THE TA)-ZWT*SIN( THE TA)
ZB=XWT*SIN( THE TA)+ZWT*COS( THE TA)
T9= BLD -YP
T10=XB-XP
XLHIP= SQRT(TS*TS + T10*T10)
BHIP= ATAN2(TS,T10)
XLHI= SQRT(XLHIP*XLHIP -RAD*RAD)
DBHI= ATAN(RAD/XLHI)
BHI= BHIP -DBHI
T11=ZB-ZP
XL=SQRT(XLHI*XLHI+T11*T11)
TH10=T10-RAD*COS(BHI)
TH9=T9-RAD*SIN(BHI)
IF( IF.EQ.3)GO TO 3
XLGTH( 1)=XL
XLGTH( 2)=XL
ADC( 1, 1)=ARCCOS( TH10/XL)
ADC( 1, 2)=ARCCOS( TH9/XL)
ADC( 1, 3)=ARCCOS( T11/XL)
ADC( 2, 1)=-ADC( 1, 1)
ADC( 2, 2)=PI-ADC( 1,2)
ADC( 2, 3)=ADC( 1, 3)
ARM( 1, 1)=XP-RAD*SIN(BHI )
ARM( 1, 2)=YP+RAD*COS(BHI )
ARM( 1, 3)=0.
ARM( 2, 1)=ARM( 1, 1)
ARM( 2, 2)=-ARM( 1, 2)
ARM( 2, 3)=0.
RETURN
3 XLGTH( 3)=XL
XLGTH( 4)=XL
ADC( 3, 1)=ARCCOS( TH10/XL)
ADC( 3, 2)=ARCCOS( TH9/XL)
ADC( 3, 3)=ARCCOS( T11/XL)
ADC( 4, 1)=-ADC( 3, 1)
ADC( 4, 2)=PI-ADC( 3,2)
ADC( 4, 3)=ADC( 3, 3)
ARM( 3, 1)=XP+RAD*SIN(BHI )
ARM( 3, 2)=YP-RAD*COS(BHI )
ARM( 3, 3)=0.
ARM( 4, 1)=ARM( 3, 1)
ARM( 4, 2)=-ARM( 3, 2)
ARM( 4, 3)=0.
RETURN
END
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CBL 09360
CBL 09370
CBL 09380
CBL 09390
CBL 09400
CBL 09410
CBL 09420
CBL 09430
CBL 09440
CBL 09450
CBL 09460
CBL 09470
CBL 09480
CBL 09490
CBL 09500
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CBL 09840
CBL 09850
CBL 09860
CBL 09870
CBL 09880
CBL 09890
CBL 09900

FILE CABLE FORTRAN PI

G F U N K A N D A T A S Y S T E M S

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SUBROUTINE DLGTH(C1,C2,C3,IC,IDX)                               CBL 09910
C COMPUTES DEL-LGTH EQ FOR X-Z-THETA OR Y-FSI-FHI CCEFF          CBL 09920
COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF        CBL 09930
IF( ICX .NE. C )GO TO 1                                         CBL 09940
C1=-COS(ADC(IC,1))                                              CBL 09950
C2=-COS(ADC(IC,3))                                              CBL 09960
C3=(ARM(IC,1)*COS(ADC(IC,3))-ARM(IC,3)*COS(ADC(IC,1)))/12.    CBL 09970
RETURN                                                       CBL 09980
1 C1=-COS(ADC(IC,2))                                              CBL 09990
C2=(ARM(IC,2)*COS(ADC(IC,1))-ARM(IC,1)*COS(ADC(IC,2)))/12.    CBL 10000
C3=(ARM(IC,3)*COS(ADC(IC,2))-ARM(IC,2)*COS(ADC(IC,3)))/12.    CBL 10010
RETURN                                                       CBL 10020
END
SUBROUTINE DCOSLG(IC,CX1,CZ1,CT1,CX3,CZ3,CT3)                  CBL 10030
C COMPUTES D-CIR COS EQS FOR X-Z-THETA CCEFF.                   CBL 10040
COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF        CBL 10050
CX1=SIN(ADC(IC,1))/XLGTH(IC)*12.                                CBL 10060
CZ1=-COS(ADC(IC,3))*COTAN(ADC(IC,1))/XLGTH(IC)*12.            CBL 10070
XWT=ARM(IC,1)                                                 CBL 10080
ZWT=ARM(IC,3)                                                 CBL 10090
CT1=(ZWT*SIN(ADC(IC,1))+XWT*COS(ADC(IC,3))*COTAN(ADC(IC,1)))/ CBL 10110
1XLGTH(IC)                                                 CBL 10120
CX3=-COS(ADC(IC,1))*COTAN(ADC(IC,3))/XLGTH(IC)*12.            CBL 10130
CZ3=SIN(ADC(IC,3))/XLGTH(IC)*12.                                CBL 10140
CT3=-(ZWT*COS(ADC(IC,1))*COTAN(ADC(IC,3))+XWT*SIN(ADC(IC,3)))/ CBL 10150
1XLGTH(IC)                                                 CBL 10160
RETURN                                                       CBL 10170
END
C THIS IS A SINGLE PRECISION VERSION OF CABLE4 TC BE USED
C WITH THE LRC MATRIX REDUCTION AND IBM RCCT                      CBL 10190
C FINDING ROUTINE
SUBROUTINE LONG
COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL                  CBL 10220
COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF        CBL 10230
COMMON /DU/DUM(10,10)
EQUIVALENCE(AERO(46),XCG),(AERC(47),ZCG)                         CBL 10240
EQUIVALENCE(AERO(63),THETA),(AERO(49),VC),(AERC(50),AM)           CBL 10250
EQUIVALENCE(AERO(51),RHO),(AERO(52),WT),(AERO(53),B)              CBL 10260
EQUIVALENCE(AERO(54),CBAR),(AERO(55),SV),(AERO(56),XIXZ)           CBL 10270
EQUIVALENCE(AERO(57),XIXX),(AERO(58),YIYY),(AERC(56),ZIZZ)           CBL 10280
1 (AERO(55),AKR),(AERO(100),AKLFT)                                CBL 10290
EQUIVALENCE(AERO(123),AKSY),(AERO(124),AKFHI),(AERC(125),AKTHE), CBL 10300
1 (AERO(126),AKAZ),(AERO(127),T1SY),(AERC(128),T2PHI).          CBL 10310
2 (AERO(129),T3THE),(AERO(130),T4A2)                                CBL 10320
EQUIVALENCE(AEROP(1),CXLP),(AEROP(2),C2UF),(AERCP(3),CMUP),       CBL 10330
1 (AEROP(4),CXAP),(AEROP(5),CZAF),(AERCP(6),CMAP),               CBL 10340
2 (AEROP(7),CXQP),(AEROP(8),CZCF),(AERCP(9),CMQP),               CBL 10350
3 (AEROP(10),CXOP),(AEROP(11),CZCF),(AEROP(12),CMOP),               CBL 10360
4 (AEROP(13),CXDEP),(AEROP(14),C2CEF),(AERCP(15),CMDEP),          CBL 10370
5 (AEROP(16),CXADP),(AEROP(17),CZACF),(AERCP(18),CMADP),          CBL 10380
6 (AEROP(19),CYBP),(AEROP(20),CLEF),(AEROP(21),CNBP),             CBL 10390
7 (AEROP(22),CYPP),(AEROP(23),CLFF),(AERCP(24),CNPP),             CBL 10400
8 (AEROP(25),CYRP),(AEROP(26),CLRF),(AERCP(27),CNRP),             CBL 10410
9 (AEROP(28),CYDRP),(AEROP(29),CLCRP),(AERCP(30),CNDRP),           CBL 10420
A (AEROP(31),CYDAP),(AEROP(32),CLDAF),(AEROP(33),CNDAP),           CBL 10430

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B          (AEROP(34),CYDSP), (AEROP(35),CLCSF), (AERCF(36),CNDSF)    CBL 10460
DIMENSION CMAT(7,7,3)                                              CBL 10470
COMPLEX ROOTS(29)                                                 CBL 10480
COMMON/SNUBB/SNU(3,3)*SN(30),THUSN,THLSN,SNUC(3,3)               CBL 10490
COMMON /ROUGH/FRIC(3,6)                                            CBL 10500
DIMENSION FXS(3,4)                                                 CBL 10510
DO 10 J=1,3                                                       CBL 10520
DO 10 K=1,4                                                       CBL 10530
10 FXS(J,K)=0.
DO 1 IC=1,5                                                       CBL 10540
DO 3 J=1,10                                                       CBL 10550
DO 3 K=1,10                                                       CBL 10560
3 DUM(J,K)=0.
TENS=TF
IF( IC.GT.2) TENS=TR
IF( IC.GT.4) TENS=TLFT
DUM(1,2)= - TENS * COS(ADC(IC,3))
DUM(1,5)= - TENS * SIN(ADC(IC,1))
DUM(2,2)= TENS * COS(ADC(IC,1))
DUM(2,6)= - TENS * SIN(ADC(IC,3))
DUM(3,2)=( ARM(IC,3)*DUM(1,2)-ARM(IC,1)*DLN(2,2))/12.
DUM(3,5)= ARM(IC,3)*DLM(1,5)/12.
DUM(3,6)= -ARM(IC,1)*DUM(2,6)/12.
IF( IC.GT.2) GO TO 2
DUM(1,3)=COS(ADC(IC,1))
DUM(2,3)=COS(ADC(IC,3))
DUM(3,3)=(ARM(IC,3)*DUM(1,3)-ARM(IC,1)*DLN(2,3))/12.
CALL DLGTH(CX,CZ,CT,1,0)
CALL DLGTH(CXP,CZP,CTP,2,C)
CX = CX + CXP
XPZ =-(CZ+CZP)/CX
DUM(4,1) =XPZ
XPT =-(CT+CTP)/CX
DUM(4,2)=XPT
DUM(4,4)= -1
CALL DCOSLG(IC,DUM(5,4),DUM(5,1),DLM(5,2),DUN(6,4),
1DUM(6,1),DLM(6,2))
DUM(6,5)= -1
DUM(6,6)= -1
CALL MASH(3,6)
DO 4 J=1,3
DO 4 K=1,3
4 FXS(J,K)=FXS(J,K)+DUM(J,K)
GO TO 1
2 IF( IC.GT.4)GO TO 5
DUM(1,4)=COS(ADC(IC,1))
DUM(2,4)=COS(ADC(IC,3))
DUM(3,4)=(ARM(IC,3)*DUM(1,4)-ARM(IC,1)*DLN(2,4))/12.
CALL DLGTH(CX,CZ,CT,3,0)
CALL DLGTH(CXP,CZP,CTP,4,C)
DUM(7,1)=CZ+CZP
DUM(7,2)=CT+CTP
DUM(7,3)=CX+CXP
DUM(4,7)=AKR*12.
3 CALL DCOSLG(IC,DUM(5,3),DUM(5,1),DLM(5,2),DUN(6,3),DUM(6,1),DUM
CBL 10570
CBL 10580
CBL 10590
CBL 10600
CBL 10610
CBL 10620
CBL 10630
CBL 10640
CBL 10650
CBL 10660
CBL 10670
CBL 10680
CBL 10690
CBL 10700
CBL 10710
CBL 10720
CBL 10730
CBL 10740
CBL 10750
CBL 10760
CBL 10770
CBL 10780
CBL 10790
CBL 10800
CBL 10810
CBL 10820
CBL 10830
CBL 10840
CBL 10850
CBL 10860
CBL 10870
CBL 10880
CBL 10890
CBL 10900
CBL 10910
CBL 10920
CBL 10930
CBL 10940
CBL 10950
CBL 10960
CBL 10970
CBL 10980
CBL 10990
CBL 11000

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1(6,2)
DUM(4,4)=-1
DUM(5,5)=-1
DJM(6,6)=-1
DUM(7,7)=-1
CALL MASH(3,7)
DO 6 J=1,3
DO 6 K=1,3
IF(K.NE.3)FXS(J,K)=FXS(J,K)+DLN(J,K)
6 IF(K.EQ.3)FXS(J,4)=FXS(J,4)+DLN(J,K)
GO TO 1
5 IF(KODE(11).EQ.0)GO TO 1
CALL DLGTH(DUM(7,3)+DUM(7,1)+DUM(7,2)+5,0)
DUM(4,7)=AKLFT*12.
GO TO 8
1 CONTINUE
ADD SNUBBER INCREMENTS
CALL LONGSN
DO 7 J=1,3
FXS(J,1)=FXS(J,1)+SNU(J,2)
FXS(J,2)=FXS(J,2)+SNU(J,3)
7 FXS(J,4)=FXS(J,4)+SNU(J,1)
CALL FRIC(0)
THE CABLE FORCES/MOMENTS PARTIALS ARE COMPUTED
AERO. DATA IS NOW COMPUTED
Q=RHO*VO*VO/2.
QS=Q*SW
QSV=QS/VO
XU=CXUP*QSV
ZU=CZUP*QSV
EMU=CMUP*QSV*CBAR
XA=CXAP*QSV
ZA=CZAP*QSV
EMA=CMAP*QSV*CBAR
XQ=CXQP*QSV*CBAR/(VO*2.)
ZQ=CZQP*QSV*CBAR/(VO*2.)
EMQ=CMQP*QSV*CBAR/2.
XDE=CXDEP*QS
ZDE=CZDEP*QS
EMDE=CMDFP*QS*CBAR
XAD=CXADP*QSV*CBAR/(VO*2.)
ZAD=CZADP*QSV*CBAR/(VO*2.)
EMAD=CMADP*QSV*CBAR/(2.*VO)
IROW=7
ICOL=7
IORDER=3
DO 20 I=1,IROW
DO 20 J=1,ICOL
DO 20 K=1,IORDER
20 CMAT(I,J,K)=0.
FX EQUATION
CMAT(1,1,1)=-FXS(1,1)
CMAT(1,1,2)=-XA-SNU(1,2)-FRIC(1,5)-FRIC(1,2)
CMAT(1,1,3)=-XAD
CMAT(1,2,1)=-FXS(1,2)+WT*COS(THETA)-XA*VC
CBL 11010
CBL 11020
CBL 11030
CBL 11040
CBL 11050
CBL 11060
CBL 11070
CBL 11080
CBL 11090
CBL 11100
CBL 11110
CBL 11120
CBL 11130
CBL 11140
CBL 11150
CBL 11160
CBL 11170
CBL 11180
CBL 11190
CBL 11200
CBL 11210
CBL 11220
CBL 11230
CBL 11240
CBL 11250
CBL 11260
CBL 11270
CBL 11280
CBL 11290
CBL 11300
CBL 11310
CBL 11320
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CBL 11340
CBL 11350
CBL 11360
CBL 11370
CBL 11380
CBL 11390
CBL 11400
CBL 11410
CBL 11420
CBL 11430
CBL 11440
CBL 11450
CBL 11460
CBL 11470
CBL 11480
CBL 11490
CBL 11500
CBL 11510
CBL 11520
CBL 11530
CBL 11540
CBL 11550

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FILE CABLE FORTRAN PI

G F L P P A R DATA SYSTEMS

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CMAT(1,2,2)=-XQ-XAD*VO-SNUD(1,3)-FRIC(1,6)-FRIC(1,3)          CBL 11560
CMAT(1,2,3)=ZCG*AM/12.                                              CBL 11570
CMAT(1,3,1)=-FXS(1,3)                                              CBL 11580
CMAT(1,4,1)=-FXS(1,4)                                              CBL 11590
CMAT(1,4,2)=-XL-SNUD(1,1)-FRIC(1,4)-FRIC(1,1)                  CBL 11600
CMAT(1,4,3)=AM                                              CBL 11610
CMAT(1,5,1)=-XDE                                              CBL 11620
C EQUATION
CMAT(2,1,1)=-FXS(2,1)                                              CBL 11630
CMAT(2,1,2)=-ZA-SNUD(2,2)-FRIC(2,5)-FRIC(2,2)                  CBL 11640
CMAT(2,1,3)=AM-ZAD                                              CBL 11650
CMAT(2,2,1)=-FXS(2,2)+WT*SIN(THETA)-ZA*VC                      CBL 11660
CMAT(2,2,2)=-ZO-ZAD*VO-SNUD(2,3)-FRIC(2,6)-FRIC(2,3)          CBL 11670
CMAT(2,2,3)=-XCG*AM/12.                                              CBL 11680
CMAT(2,3,1)=-FXS(2,3)                                              CBL 11690
CMAT(2,4,1)=-FXS(2,4)                                              CBL 11700
CMAT(2,4,2)=-ZL-SNUD(2,1)-FRIC(2,4)-FRIC(2,1)                  CBL 11710
CMAT(2,5,1)=-ZDE                                              CBL 11720
C MOMENT EQUATION
CMAT(3,1,1)=-FXS(3,1)                                              CBL 11730
CMAT(3,1,2)=-EMA-SNUD(3,2)-FRIC(3,5)-FRIC(3,2)                  CBL 11740
CMAT(3,1,3)=-EMAD*CBAR+XCG*AM/12.                                  CBL 11750
CMAT(3,2,1)=-FXS(3,2)-EMA*VO+2CG*WT*CCS(THETA)/12.              CBL 11760
1-XCG*WT*SIN(THETA)/12.                                              CBL 11770
CMAT(3,2,2)=(-EMQ-EMAD*VO)*CBAR-SNUD(3,3)-FRIC(3,6)-FRIC(3,3) CBL 11780
CMAT(3,2,3)=YIYY                                              CBL 11790
CMAT(3,3,1)=-FXS(3,3)                                              CBL 11800
CMAT(3,4,1)=-FXS(3,4)                                              CBL 11810
CMAT(3,4,2)=-FML-SNUD(3,1)-FRIC(3,4)-FRIC(3,1)                  CBL 11820
CMAT(3,4,3)=ZCG*AM/12.                                              CBL 11830
CMAT(3,5,1)=-EMDE                                              CBL 11840
C CONSTRAINT EQUATION
CMAT(4,1,1)=-XPZ                                              CBL 11850
CMAT(4,2,1)=-XPT                                              CBL 11860
CMAT(4,4,1)=1                                              CBL 11870
C FEEDBACK LOOP EQUATION
CMAT(5,2,2)=AK THE                                              CBL 11880
CMAT(5,5,2)=-T4THE                                              CBL 11890
CMAT(5,5,1)=-1.                                              CBL 11900
IW=6                                              CBL 11910
N=KODE(8)                                              CBL 11920
CALL MATRIX(CMAT,N,ROOTS,K4A,IER)
IF(KODE(5).NE.0) WRITE(IW,100) IER
100 FORMAT(2X,'IER=',13.3X,'SEE SUBR. PGFB AND FREN FOR ERROR CODE')
C THE ROOTS OF THE CHARAC. EQUAT. ARE IN THE COMPLEX ARRAY 'ROOTS'
C AND THE NUMBER OF ROOTS IS 'K4A'.
CALL PRINTR(IW,ROOTS,K4A)
RETURN
END
SUBROUTINE PRINTR(LOUT,RT,NRCCT)
DIMENSION RT(2,1)
COMMENT PRINTS PERTINENT INFORMATION ABOUT CHARACTERISTIC ROOTS
WRITE(LOUT,507)
507 FORMAT(      *      REAL      IMAGINARY      T H/D-SEC      1/T H/, CBL 12090
1          *D      PERIOD-SEC      DRATF-CFS      UNDRAT-CPS      DAMP *, CBL 12100

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2           *RATIO      DECAY RATIC   )CBL 12110
NEXT=1
DO 530 I=1,NROOT
IF(NFXT.EQ.2) GO TO 777
SIG=RT(1,I)
ASIG=ABS(SIG)
AWD=ABS(RT(2,I))
THDI= ASIG*1.442655
THD= 99999.
IF( THDI.GT.1.E-5) THD= 1./THDI
IF(AWD.EQ.0.) GO TO 531
NEXT=2
WD=-AWD
DNAT= AWD * .159155
PER= 99999.
IF(DNAT.GT.1.E-5) PER= 1./DNAT
UNDNAT= SQRT(ASIG**2+AWD**2) *.1591550
DAMPR= 0.
IF( AWD - 1.E15 * ASIG ) 503,504,504
503 DAMPR= SIGN ( COS( ATAN ( AWD/ASIG ) ), -SIG )
504 CHDI= THDI*PER
DECR= 99999.
ARG= SIG * PER
IF(ARG.LT.-174.6) DECR= EXP (ARG)
WRITE(LOUT,529) SIG,WD,THD,THDI,PER,DNAT,LNEXT,DAMPR,CHDI,DECR
529 FORMAT(1PE12.4,2X,1H+,1PE11.4,1P8E13.4)
GO TO 530
5   WRITE(LOUT,532) SIG,THD,THDI
532 FORMAT(1PE12.4,14X,2E13.4)
GO TO 530
777 NEXT=1
530 CONTINUE
RETURN
END
SUBROUTINE MASH (NN,N)
COMMON /DU/DUM(10,10)
C NN = FINAL MATRIX SIZE
C N = ORIGINAL MATRIX SIZE
INN=N-NN
DO 1001 LL=1,INN
L=N+1-LL
II=L-1
JJ=L-1
DO 1001 I=1,II
DO 1001 J=1,JJ
1001 DUM(I,J)= DUM(I,J)+DUM(L,J)*DUM(I,L)/(-DUM(L,L))
RETURN
END
SUBROUTINE LAT
COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL
COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),AFN(5,3),TR,TLFT,TF
COMMON /DU/DUM(10,10)
EQUIVALENCE(AERO(46), XCG),(AERO(47), ZCG)
EQUIVALENCE(AERO(63),THE TA),(AERO(49),YC ),(AERC(50), AM)
EQUIVALENCE(AERO(51),RHO ),(AERO(52), WT),(AERO(53),B )
)CBL 12120
)CBL 12130
)CBL 12140
)CBL 12150
)CBL 12160
)CBL 12170
)CBL 12180
)CBL 12190
)CBL 12200
)CBL 12210
)CBL 12220
)CBL 12230
)CBL 12240
)CBL 12250
)CBL 12260
)CBL 12270
)CBL 12280
)CBL 12290
)CBL 12300
)CBL 12310
)CBL 12320
)CBL 12330
)CBL 12340
)CBL 12350
)CBL 12360
)CBL 12370
)CBL 12380
)CBL 12390
)CBL 12400
)CBL 12410
)CBL 12420
)CBL 12430
)CBL 12440
)CBL 12450
)CBL 12460
)CBL 12470
)CBL 12480
)CBL 12490
)CBL 12500
)CBL 12510
)CBL 12520
)CBL 12530
)CBL 12540
)CBL 12550
)CBL 12560
)CBL 12570
)CBL 12580
)CBL 12590
)CBL 12600
)CBL 12610
)CBL 12620
)CBL 12630
)CBL 12640
)CBL 12650

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EQUIVALENCE(AERO(54),CBAR),(AERO(55),EV),(AEFC(56),XIXZ) CBL 12660
EQUIVALENCE(AERO(57),XIXX),(AERO(58),VYY),(AEFC(59),ZIZZ) CBL 12670
1   (AERO(95),AKR),(AERO(100),AKLFT) CBL 12680
EQUIVALENCE(AERO(123),AKSY),(AERO(124),AFFHI),(AEFC(125),AKTHE) CBL 12690
1   (AERO(126),AKAZ),(AERO(127),T1SY),(AEFC(128),T2PHI) CBL 12700
2   (AERO(129),T3THE),(AERO(130),T4A2) CBL 12710
EQUIVALENCE(AEROP(1),CXUP),(AEROP(2),C2LF),(AEROP(3),CMUP) CBL 12720
1   (AEROP(4),CXAP),(AEROP(5),C2AF),(AEROP(6),CMAP) CBL 12730
2   (AEROP(7),CXQP),(AEROP(8),C2CF),(AERCF(9),CMQP) CBL 12740
3   (AEROP(10),CXOP),(AEROP(11),C2CF),(AEROP(12),CMOP) CBL 12750
4   (AEROP(13),CXDEP),(AEROP(14),C2DEP),(AEROP(15),CMDEP) CBL 12760
5   (AEROP(16),CXADP),(AEROP(17),C2ACF),(AERCF(18),CMADP) CBL 12770
6   (AEROP(19),CYBP),(AEROP(20),CLEF),(AEROP(21),CNBP) CBL 12780
7   (AEROP(22),CYPP),(AEROP(23),CLFF),(AEFC(24),CNPP) CBL 12790
8   (AEROP(25),CYRP),(AEROP(26),CLFF),(AERCP(27),CNRP) CBL 12800
9   (AEROP(28),CYDRP),(AEROP(29),CLCFF),(AERCP(30),CNDRP) CBL 12810
A   (AEROP(31),CYDAP),(AEROP(32),CLCAF),(AEROP(33),CNDAP) CBL 12820
B   (AEROP(34),CYDSP),(AEROP(35),CLCSF),(AERCP(36),CNDSP) CBL 12830
DIMENSION CMAT(7,7,3) CBL 12840
COMPLEX ROOTS(29) CBL 12850
COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUC(3,3) CBL 12860
COMMON /ROUGH/FRIC(3,6) CBL 12870
DIMENSION FXS(3,3) CBL 12880
DO 10 J=1,3 CBL 12890
DO 10 K=1,3 CBL 12900
10 FXS(J,K)=0. CBL 12910
DO 111 IC=1,5 CBL 12920
IF(KODE(11).EQ.0.AND.IC.EQ.5)GC TO 1 CBL 12930
DO 3 J=1,8 CBL 12940
DO 3 K=1,8 CBL 12950
3 DUM(J,K)=0. CBL 12960
TENS=TF CBL 12970
IF(IC.GT.2)TENS=TR CBL 12980
IF(IC.GT.4)TENS=TLFT CBL 12990
CA1=COS(ADC(IC,1)) CBL 13000
CA2=COS(ADC(IC,2)) CBL 13010
CA3=COS(ADC(IC,3)) CBL 13020
IF(ABS(CA1).LT..CC01) CA1=0. CBL 13030
IF(ABS(CA2).LT..0C01) CA2=0. CBL 13040
IF(ABS(CA3).LT..0C01) CA3=0. CBL 13050
DUM(1,2)=-TENS*CA1 CBL 13060
DUM(1,3)=TENS*CA3 CBL 13070
DUM(1,4)=CA2 CBL 13080
DUM(1,6)=-TENS*SIN(ADC(IC,2)) CBL 13090
DUM(2,2)=(ARM(IC,1)*DUM(1,2)-ARM(IC,2)*TENS*CA2)/12. CBL 13100
DUM(2,3)=ARM(IC,1)*DUM(1,3)/12. CBL 13110
DUM(2,4)=(ARM(IC,1)*CA2-ARM(IC,2)*CA1)/12. CBL 13120
DUM(2,5)=ARM(IC,2)*TENS*SIN(ADC(IC,1))/12. CBL 13130
DUM(2,6)=ARM(IC,1)*DUM(1,6)/12. CBL 13140
DUM(4,4)=-1. CBL 13150
DUM(4,6)=0. CBL 13160
IF(IC.GT.2)DUM(4,6)=AKR*12. CBL 13170
IF(IC.GT.4)DUM(4,6)=AKLFT*12. CBL 13180
DUM(3,2)=-ARM(IC,3)*DUM(1,2)/12. CBL 13190
DUM(3,3)=(-ARM(IC,3)*DUM(1,3)-ARM(IC,2)*TENS*CA2)/12. CBL 13200

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FILE CABLE FORTRAN P1

G F L U N K A N D A T A S Y S T E M S

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DUM( 3, 4)=(ARM( IC, 2)*CA3-ARM( IC, 3)*CA2)/12.          CBL 13210
DUM( 3, 7)=-ARM( IC, 2)*TENS* SIN(ADC(IC,1))/12.        CBL 13220
DUM( 3, 6)=-ARM( IC, 3)*DUM(1,6)/12.                    CBL 13230
CALL DCOSD( IC,DUM(5,1),DUM(5,2),DUM(5,3),CLN(6,1),CUN(6,2),DUM(
16, 3),DUM( 7, 1),DUM( 7, 2),DUM( 7, 3))               CBL 13240
DUM( 5, 5)=- 1.                                         CBL 13250
DJM( 6, 6)=- 1.                                         CBL 13260
DUM( 7, 7)=- 1.                                         CBL 13270
IF( IC.GT.2)GO TO 2                                     CBL 13280
CALL MASH( 3, 7)                                       CBL 13290
6 DO 4 J=1,3                                           CBL 13300
DO 4 K=1,3                                           CBL 13310
4 FXS( J,K)=FXS( J,K)+DUM( J,K)                      CBL 13320
GO TO 1                                               CBL 13330
2 IF( IC.GT.4)GO TO 5                                     CBL 13340
CALL DLGTH(CY,CPS,CPH,3,1)                            CBL 13350
CALL DLGTH(CYP,CP SP,CPHP,4,1)                         CBL 13360
DUM( 5, 1)=CY+CYP                                      CBL 13370
DUM( 5, 2)=CPS+CP SP                                 CBL 13380
DUM( 5, 3)=CPH+CPHP                                 CBL 13390
DUM( 5, 8)=- 1.                                         CBL 13400
CALL MASH( 3, 8)                                       CBL 13410
GO TO 6                                               CBL 13420
5 IF(KODE( 11).EQ.0)GO TO 1                           CBL 13430
CALL DLGTH(DUM(8,1),DUM(8,2),DLM(8,3),5,1)           CBL 13440
DUM( 5, 8)=- 1.                                         CBL 13450
GO TO 6                                               CBL 13460
CONTINUE                                              CBL 13470
111 CONTINUE                                            CBL 13480
112 COMPLETE SUMMATION OF CABLE FORCES & MOMENTS       CBL 13490
ADD SNUBBER INCREMENTS                                CBL 13500
112 CALL LATSN                                         CBL 13510
DO 9 J=1,3                                           CBL 13520
DO 9 K=1,3                                           CBL 13530
8 FXS( J,K)=FXS( J,K)+SNU( J,K)                      CBL 13540
CALL FRICT( 1)                                         CBL 13550
ADD AERO INCREMENTS                                CBL 13560
Q=.5*RHO*VO*VO                                       CBL 13570
QS=Q*SW                                              CBL 13580
QSV=QS/VO                                           CBL 13590
BOV=B/(2.*VO)                                         CBL 13600
YV=CYBP*QSV                                         CBL 13610
ELV=CL BP*QSV*B                                       CBL 13620
ENV=CNBP*QSV*B                                       CBL 13630
YP=CYP*QS*BOV                                         CBL 13640
EL_P=CLPP*BOV*QS*B                                  CBL 13650
ENP=CNPP*BOV*QS*B                                  CBL 13660
YR=CYRP*QS*BOV                                         CBL 13670
EL_R=CLR_P*BOV*QS*B                                 CBL 13680
ENR=CNRP*BOV*QS*B                                 CBL 13690
YDR=CYDRP*QS                                         CBL 13700
ENDR=CNDRP*QS*B                                    CBL 13710
EL_DR=CL DRP*QS*B                                 CBL 13720
YDA=CYDAP*QS                                         CBL 13730
ENDA=CNDAP*QS*B                                    CBL 13740
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FILE CABLE FORTRAN P1

G F U N N A R D A T A S Y S T E M S

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EL DA=CLDAP*QS*B          CBL 13760
YDS=CYDSP*QS              CBL 13770
EN DS=CNDSP*QS*B          CBL 13780
EL DS=CLDSP*QS*B          CBL 13790
DO 113 I=1,7               CBL 13800
DO 113 J=1,7               CBL 13810
DO 113 K=1,3               CBL 13820
113 CMAT(I,J,K)=0.         CBL 13830
C Y FORCE EQUATION        CBL 13840
CMAT(1,1,1)=-FXS(1,1)      CBL 13850
CMAT(1,1,2)=-YV-SNUD(1,1)-FRIC(1,4)-FRIC(1,1) CBL 13860
CMAT(1,1,3)=AM             CBL 13870
CMAT(1,2,1)=-FXS(1,2)+YV*VO-WT*SIN(THETA) CBL 13880
CMAT(1,2,2)=-YR-SNUD(1,2)-FRIC(1,5)-FRIC(1,2) CBL 13890
CMAT(1,2,3)=AM*XCG/12.     CBL 13900
CMAT(1,3,1)=-FXS(1,3)-WT*COS(THETA) CBL 13910
CMAT(1,3,2)=-YP-SNUD(1,3)-FRIC(1,6)-FRIC(1,3) CBL 13920
CMAT(1,3,3)=-AM*ZCG/12.     CBL 13930
CMAT(1,4,1)=-QS*CYDRP      CBL 13940
CMAT(1,5,1)=-QS*CYDAP      CBL 13950
C YAW EQUATION            CBL 13960
CMAT(2,1,1)=-FXS(2,1)      CBL 13970
CMAT(2,1,2)=-ENV-SNUD(2,1)-FRIC(2,4)-FRIC(2,1) CBL 13980
CMAT(2,1,3)=AM*XCG/12.     CBL 13990
CMAT(2,2,1)=-FXS(2,2)+ENV*VO-XCG*WT*SIN(THETA)/12. CBL 14000
CMAT(2,2,2)=-ENR-SNUD(2,2)-FRIC(2,5)-FRIC(2,2) CBL 14010
CMAT(2,2,3)=ZIZZ           CBL 14020
CMAT(2,3,1)=-FXS(2,3)+XCG*WT*CCS(THETA)/12. CBL 14030
CMAT(2,3,2)=-ENP-SNUD(2,3)-FRIC(2,6)-FRIC(2,3) CBL 14040
CMAT(2,3,3)=-XIIXZ         CBL 14050
CMAT(2,4,1)=-QS*B*CNDRP    CBL 14060
CMAT(2,5,1)=-QS*R*CNDAP    CBL 14070
C ROLL EQUATION           CBL 14080
CMAT(3,1,1)=-FXS(3,1)      CBL 14090
CMAT(3,1,2)=-ELV-SNUD(3,1)-FRIC(3,4)-FRIC(3,1) CBL 14100
CMAT(3,1,3)=-AM*ZCG/12.     CBL 14110
CMAT(3,2,1)=-FXS(3,2)+ELV*VO-ZCG*WT*SIN(THETA)/12. CBL 14120
CMAT(3,2,2)=-ELR-SNUD(3,2)-FRIC(3,5)-FFIC(3,2) CBL 14130
CMAT(3,2,3)=-XIIXZ         CBL 14140
CMAT(3,3,1)=-FXS(3,3)-ZCG*WT*COS(THETA)/12. CBL 14150
CMAT(3,3,2)=-ELP-SNUD(3,3)-FRIC(3,6)-FFIC(3,3) CBL 14160
CMAT(3,3,3)=XIIXX           CBL 14170
CMAT(3,4,1)=-QS*B*CLDRP    CBL 14180
CMAT(3,5,1)=-QS*B*CLDAP    CBL 14190
C RUDDER FEEDBACK LOOP    CBL 14200
CMAT(4,2,2)=AKSY           CBL 14210
CMAT(4,4,2)=-TESY           CBL 14220
CMAT(4,4,1)=-1.              CBL 14230
C AILERON FEEDBACK LOOP    CBL 14240
CMAT(5,3,2)=AKPHI           CBL 14250
CMAT(5,5,2)=-TEPHI           CBL 14260
CMAT(5,5,1)=-1.              CBL 14270
IW=6                         CBL 14280
N=KODE(9)                   CBL 14290
CALL MATRIX(CMAT,N,ROOTS,K4A,IER) CBL 14300

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      IF(KODE(5).NE.0) WRITE(IW,100) IER
100 FORMAT(2X,'IER='',I3,3X,'SEE SLBR. PQFB AND FREN FOR ERROR CODE')
C   HE ROOTS OF THE CHARACTERISTIC EQLAT. ARE IN THE COMPLEX ARRAY
C   'ROOTS' AND THE NUMBER OF ROOTS IS 'K4A'
      CALL PRINTR(IW,ROOTS,K4A)
      RETURN
      END

      SUBROUTINE DCOSD(IC,CY1,CPSI1,CPHI1,CY2,CPSI2,CPHI2,CY3,CPSI3,
1CPH13)
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),AFN(E,3),TR,TLFT,TF
      XWT=ARM( IC,1)
      YWT=ARM( IC,2)
      ZWT=ARM( IC,3)
      CY1=-COS(ADC( IC,2))*COTAN(ADC( IC,1))/XLGTH( IC)*12.
      CPSI1=-(YWT*SIN(ADC( IC,1))+XWT*COS(ADC( IC,2))*CCTAN(ADC( IC,1)))
      1/XLGTH( IC)
      CPHI1=(ZWT*COS(ADC( IC,2))*COTAN(ADC( IC,1))-YWT*CCS(ADC( IC,3))*1
      COTAN( ADC( IC,1)))/XLGTH( IC)
      CY2=SIN(ADC( IC,2))/XLGTH( IC)*12.
      CPSI2=(YWT*COS(ADC( IC,1))*COTAN(ADC( IC,2))+XWT*SIN(ADC( IC,2)))/
      1XLGTH( IC)
      CPHI2=-(ZWT*SIN(ADC( IC,2))+YWT*COS(ADC( IC,3))*CCTAN(ADC( IC,2)))
      1/XLGTH( IC)
      CY3=-COS(ADC( IC,2))*COTAN(ADC( IC,3))/XLGTH( IC)*12.
      CPSI3=(YWT*COS(ADC( IC,1))*COTAN(ADC( IC,3))-XWT*CCS(ADC( IC,2))*1
      COTAN( ADC( IC,2)))/XLGTH( IC)
      CPHI3=(ZWT*COS(ADC( IC,2))*COTAN(ADC( IC,3))+YWT*SIN(ADC( IC,3)))
      1/XLGTH( IC)
      RETURN
      END

      SUBROUTINE SNTRM (FXSN,FZEN,ANSN,THETA)
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
      COMMON ZZZ(200)
      COMMON /TAB1/ZZ(ECC)
      COMMON /SNUBB/SNU(3,3),SN(30),THUSN,THLSN,ENUD(3,3)
      EQUIVALENCE(AERO(105), SNLX),(AERO(106), SNLY),(AERC(107), SNUZ),
1          (AERO(108), SNLX),(AERO(109), SNLY),(AERC(110), SNLZ), CBL 14660
2          (AERO(111), SNLST),(AERO(112), SNLWL),(AERO(113), SNUBL), CBL 14670
3          (AERO(114), SNLST),(AERO(115), SNLWL),(AERO(116), SNLBL), CBL 14680
4          (AERO(117), TUSNO),(AERO(118), TLSNC),(AERC(119), AKSNU), CBL 14690
5          (AERO(120), AKSNL),(AERO(49), VC),(AERO(51), RHO), CBL 14700
6          (AERO(76), WLCSR),(AERO(77), STACF), CBL 14710
7          (AERO(78), BLCSR), CBL 14720
     EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1),
1          (SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2), CBL 14730
2          (SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3), CBL 14740
3          (SN(10), GX4),(SN(11), GY4),(SN(12), GZ4), CBL 14750
4          (SN(13), THU),(SN(14), THL),(SN(15), ALU), CBL 14760
5          (SN(16), ALL), CBL 14770
6          (SN(19), THGX1),(SN(20), THGY1),(SN(21), THGZ1), CBL 14780
7          (SN(22), THGX2),(SN(23), THGY2),(SN(24), THGZ2), CBL 14790
8          (SN(25), THGX3),(SN(26), THGY3),(SN(27), THGZ3), CBL 14800
9          (SN(28), THGX4),(SN(29), THGY4),(SN(30), THGZ4), CBL 14810
     IW=6
     IF(KODE(10).EQ.0) GO TO 5005

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FILE CABLE FORTRAN P1

G F U N N A R D A T A S Y S T E M S

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CALL DRCSN( THETA )                                     CBL 14860
IF(KODE( 10 ).NE.1) GO TO 5003
C TERMS TO MODEL SNUBBER EFFECTS (MCDEL UNSNUEEC)
Q=.5*RHO*V0*VO
CALL STINT(Q,ALU,C,1,1,TUSN,NG)
IF(NG.NE.0) GO TO 5000
CALL STINT(Q,ALL,0,1,1,TLSN,NG)
IF(NG.NE.0) GO TO 5000
CALL STINT(Q,ALU,C,2,2,THUSN,NG)
IF(NG.NE.0) GO TO 5000
CALL STINT(Q,ALL,C,2,2,THLSN,NG)
IF(NG.EQ.0) GO TO 5001
5000 WRITE( IW,5002 ) NG,ALL,ALU,Q
5002 FORMAT( 2X, *ERROR IN SNUBBER TABLE 1-2 , NG=*,I3,3E10.3 )
RETURN
5001 CONTINUE
C CALCULATING FORCE AND MOMENT EFFECTS
CALL DRCUSN( THETA )
FXUSN= 2.*TUSN*GX1
FZUSN= 2.*TUSN*GZ1
AMUSN= -FXLSN*SNLZ+SNLX*FZLSN
FXLSN= 2.*TLSN*GX3
FZLSN= 2.*TLSN*GZ3
AMLSN= FXLSN*SNLZ+FZLSN*SNLX
FXSN = FXUSN+FZLSN
FZSN = FZUSN+FZLSN
AMSN =(AMUSN+AMLSN)/12.
RETURN
5003 CONTINUE
C TERMS TO MODEL SNUBBER EFFECTS (MCDEL SNUBEEC)
FXUSN= 2.*TUSNO*GX1
FZUSN= 2.*TUSNO*GZ1
AMUSN =-FXUSN*SNLZ+FZUSN*SNUX
FXLSN= 2.*TLSNO*GX3
FZLSN= 2.*TLSNO*GZ3
AMLSN = FXLSN*SNLZ+FZLSN*SNLX
FXSN = FXUSN+FZLSN
FZSN = FZUSN+FZLSN
AMSN =(AMUSN+AMLSN)/12.
RETURN
5005 FXSN=0
FZSN=0
AMSN=0
RETURN
END
SUBROUTINE LONGSN
COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
COMMON /SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNDC(3,3)
COMMON ZZZ(200)
COMMON/TAB1/ZZ(800)
COMMON/DL/CUM(10,10)
EQUIVALENCE(AERO(105), SNLX),(AERO(106), SNLY),(AERC(107), SNLZ),
1           (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ), CBL 15370
2           (AERO(111), SNLST),(AERO(112), SNLWL),(AERC(113), SNUBL), CBL 15380
3           (AERO(114), SNLST),(AERO(115), SNLWL),(AERC(116), SNLBL), CBL 15390
                                         CBL 15400
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FILE CABLE FORTRAN PI

G F L N R A N DATA SYSTEMS

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4          (AERO(117),TUSNO),(AERO(118),TLSNC),(AERC(119),AKSNU),CBL 15410
5          (AERO(120),AKSNL),(AERO(49),VC),(AERC(51),RHO),CBL 15420
6          (AERO(63),THE TA),(AERO(121),ACSNL),(AERC(122),ACSNL)CBL 15430
EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1),CBL 15440
1          (SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2),CBL 15450
2          (SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3),CBL 15460
3          (SN(10), GX4),(SN(11), GY4),(SN(12), GZ4),CBL 15470
4          (SN(13), THU),(SN(14), THL),(SN(15), ALU),CBL 15480
5          (SN(16), ALL),CBL 15490
6          (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),CBL 15500
7          (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),CBL 15510
8          (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),CBL 15520
9          (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)CBL 15530
DIMENSION FTOP(3,3),FBOT(3,3)CBL 15540
COT(A)=1./TAN(A)CBL 15550
IW=6CBL 15560
DO 1001 I=1,3CBL 15570
DO 1001 J=1,3CBL 15580
SNU(I,J)=0CBL 15590
1001 SNUD(I,J)=0CBL 15600
DO 5102 I=1,10CBL 15610
DO 5102 J=1,10CBL 15620
5102 DUM(I,J)=0CBL 15630
IF(KODE(10).NE.1) GO TO 1000CBL 15640
C TERMS FOR UNSNUBBED SNUBBER EFFECTS (LCNG)
DO 1004 I=1,7CBL 15650
DO 1004 J=1,7CBL 15660
4 DUM(I,J)=0CBL 15670
CALL DRCUSN(THETA)CBL 15680
DUM(1,3)=-2.*TUSNO*GZ1CBL 15690
DUM(1,4)=-2.*TUSNO*SIN(THGX1)CBL 15700
DUM(1,6)= 2.*GX1CBL 15710
DUM(2,3)= 2.*TUSNO*GX1CBL 15720
DUM(2,5)=-2.*TUSNO*SIN(THGZ1)CBL 15730
DUM(2,6)= 2.*GZ1CBL 15740
DUM(3,3)= (-SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.CBL 15750
DUM(3,4)=-SNLZ*DUM(1,4)/12.CBL 15760
DUM(3,5)= SNLX*DUM(2,5)/12.CBL 15770
DJM(3,6)= (-SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.CBL 15780
DUM(4,1)=(SIN(THGX1)/ALL)*12.CBL 15790
DUM(4,2)= (-GZ1*COT(THGX1)/ALL)*12.CBL 15800
DUM(4,3)= -SNLZ*SIN(THGX1)/ALL-SNUX*GZ1+CCT(THGX1)/ALU
DUM(4,4)= -1.CBL 15810
DUM(5,1)= (-GX1*COT(THGZ1)/ALL)*12.CBL 15820
DUM(5,2)= (SIN(THGZ1)/ALU)*12.CBL 15830
DJM(5,3)= SNLZ*GX1*COT(THGZ1)/ALU + SNLX*SIN(THGZ1)/ALU
DUM(5,5)= -1.CBL 15840
CALL DRCSN( THE TA)CBL 15850
Q=.5*RHO*VO*VO
ALU1=ALU+1.
CALL STINT(Q,ALU1,0,1,1,TUSN1,NG)CBL 15860
IF(NG.NE.0) GO TO 5000
ALU2=ALU-1.
CALL STINT(Q,ALU2,0,1,1,TUSN2,NG)CBL 15870
IF(NG.EQ.0) GO TO 5001

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FILE CABLE FORTRAN P1

G F L M N A R DATA SYSTEMS

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5000 WRITE( IW, 5C02 ) NG,ALL,ALU,Q
5002 FORMAT('ERROR IN TABLE 1-2,NG=',I2,3XE10.3)
      RETURN
5001 CONTINUE
      AK TU=( TUSN1-TUSN2)/2.
      DUM( 6, 6)= -1.
      DUM( 6, 7)= AK TU*12.
      DUM( 7, 1)= -GX1
      DUM( 7, 2)= -GZ1
      DUM( 7, 3)= (-(SNLX+ALL*GX1)*GZ1-(SNLZ+ALL*GZ1)*GX1)/12.
      DUM( 7, 7)= -1.
      CALL MASH( 3,7 )
      DO 1005 I=1,3
      DO 1005 J=1,3
1005 FTOP( I,J)=DUM( I,J )
      CALL DRCUSN( THETA )
      DUM( 1, 3)= -2.*TL SNO*GZ3
      DUM( 1, 4)= -2.*TL SNO*SIN( THGX3 )
      DUM( 1, 6)= 2.*GX3
      DUM( 2, 3)= 2.*TL SNO*GX3
      DUM( 2, 5)= -2.*TL SNO*SIN( THGZ3 )
      DUM( 2, 6)= 2.*GZ3
      DUM( 3, 3)= (SNLZ*DUM( 1,3 )+SNLX*DUM( 2,3 ))/12.
      DUM( 3, 4)= SNLZ*DUM( 1,4 )/12.
      DUM( 3, 5)= SNLX*DUM( 2,5 )/12.
      DUM( 3, 6)= (SNLZ*DUM( 1,6 )+SNLX*DUM( 2,6 ))/12.
      DUM( 4, 1)= (SIN( THGX3 )/ALL)*12.
      DUM( 4, 2)= (-GZ3*COT( THGX3 )/ALL)*12.
      DUM( 4, 3)= SNLZ*SIN( THGX3 )/ALL - SNLX*GZ3*CCT( THGX3 )/ALL
      DUM( 4, 4)= -1.
      DUM( 5, 1)= (-GX3*COT( THGZ3 )/ALL)*12.
      DUM( 5, 2)= (SIN( THGZ3 )/ALL)*12.
      DUM( 5, 3)= -SNLZ*GX3*COT( THGZ3 )/ALL + SNLX*SIN( THGZ3 )/ALL
      DUM( 5, 5)= -1.
      CALL DRCUSN( THETA )
      ALL1=ALL+1.
      CALL STINT( Q,ALL1,0,1,1,TL SN1,NG )
      IF( NG.NE.0 ) GO TO 5003
      ALL2=ALL-1.
      CALL STINT( Q,ALL2,0,1,1,TL SN2,NG )
      IF( NG.EQ.0 ) GO TO 5004
5003 WRITE( IW, 5C02 ) NG,ALL,ALU,Q
      RETURN
5004 CONTINUE
      AK TL=( TL SN1-TL SN2)/2.
      DUM( 6, 6)= -1.
      DUM( 6, 7)= AK TL*12.
      DUM( 7, 1)= -GX3
      DUM( 7, 2)= -GZ3
      DUM( 7, 3)= (-(SNLX+ALL*GX3)*GZ3-(SNLZ+ALL*GZ3)*GX3)/12.
      DUM( 7, 7)= -1.
      CALL MASH( 3,7 )
      DO 1008 I=1,3
      DO 1008 J=1,3
1008 FBOT( I,J)=DUM( I,J )

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FILE CABLE FORTRAN P1

G F L N R A N DATA SYSTEMS

```
DO 1009 I=1,3          CBL 16510
DO 1009 J=1,3          CBL 16520
SNUD(I,J)=0            CBL 16530
1009 SNUI(I,J)=FTOP(I,J)+FBOT(I,J)
RETURN                 CBL 16540
1000 IF(KODE(10).EQ.0) GO TO 1002
C TERMS FOR SNUBRED SNUBBER EFFECTS(LONG)
CALL DRC SN(THETA)
DO 1006 I=1,7          CBL 16550
DO 1006 J=1,7          CBL 16560
1006 DUM(I,J)=0          CBL 16570
DUM(1,3)=-2.*TUSNO*GZ1  CBL 16580
DUM(1,4)=-2.*TUSNO*SIN(THGX1)  CBL 16590
DUM(1,6)=2.*GX1          CBL 16600
DUM(2,3)=2.*TUSNO*GX1    CBL 16610
DUM(2,5)=-2.*TUSNO*SIN(THGZ1)  CBL 16620
DUM(2,6)=2.*GZ1          CBL 16630
DUM(3,3)=(-SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.  CBL 16640
DUM(3,4)=-SNLZ*DUM(1,4)/12.  CBL 16650
DUM(3,5)=SNLX*DUM(2,5)/12.  CBL 16660
DUM(3,6)=(-SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.  CBL 16670
DUM(4,1)=(SIN(THGX1)/ALL)*12.  CBL 16680
DUM(4,2)=(-GZ1*COT(THGX1)/ALL)*12.  CBL 16690
DUM(4,3)=-SNUZ*SIN(THGX1)/ALL-SNUX*GZ1+CCT(THGX1)/ALU  CBL 16700
DUM(4,4)=-1.  CBL 16710
DUM(5,1)=(-GX1*COT(THGZ1)/ALL)*12.  CBL 16720
DUM(5,2)=(SIN(THGZ1)/ALL)*12.  CBL 16730
DUM(5,3)=SNLZ*GX1*COT(THGZ1)/ALU+SNLX*SIN(THGZ1)/ALU  CBL 16740
DUM(5,5)=-1.  CBL 16750
DUM(6,6)=-1.  CBL 16760
DUM(6,7)=AK SNLU*12.  CBL 16770
DUM(7,1)=-GX1          CBL 16780
DUM(7,2)=-GZ1          CBL 16790
DUM(7,3)=((-SNLX+ALU*GX1)*GZ1-(-SNUZ+ALL*GZ1)*GX1)/12.  CBL 16800
DUM(7,7)=-1.  CBL 16810
DO 10 I=1,3          CBL 16820
DO 10 J=1,3          CBL 16830
10 SNUD(I,J)=DUM(I,6)*ADSNL*DUM(7,J)*12.
CALL MASH(3,7)
DO 1007 I=1,3          CBL 16840
DO 1007 J=1,3          CBL 16850
1007 FTOP(I,J)=DUM(I,J)
DUM(1,3)=-2.*TUSNO*GZ3  CBL 16860
DUM(1,4)=-2.*TUSNO*SIN(THGX3)  CBL 16870
DUM(1,6)=2.*GX3          CBL 16880
DUM(2,3)=2.*TUSNO*GX3    CBL 16890
DUM(2,5)=-2.*TUSNO*SIN(THGZ3)  CBL 16900
DUM(2,6)=2.*GZ3          CBL 16910
DUM(3,3)=(SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.  CBL 16920
DUM(3,4)=SNLZ*DUM(1,4)/12.  CBL 16930
DUM(3,5)=SNLX*DUM(2,5)/12.  CBL 16940
DUM(3,6)=(SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.  CBL 16950
DUM(4,1)=(SIN(THGX3)/ALL)*12.  CBL 16960
DUM(4,2)=(-GZ3*COT(THGX3)/ALL)*12.  CBL 16970
DUM(4,3)=SNLZ*SIN(THGX3)/ALL-SNLX*GZ3+CCT(THGX3)/ALL  CBL 16980
CBL 16990
CBL 17000
CBL 17010
CBL 17020
CBL 17030
CBL 17040
CBL 17050
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FILE CABLE FORTRAN PI

G F U N K A R DATA SYSTEM S

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DUM( 4, 4)= -1.
DUM( 5, 1)= (-GX3*COT( THGZ3)/ALL)*12.
DUM( 5, 2)= (SIN( THGZ3)/ALL)*12.
DUM( 5, 3)= -SNLZ*GX3*COT( THGZ3)/ALL + SNLX*SIN( THGZ3)/ALL
DUM( 5, 5)= -1.
DUM( 6, 6)= -1.
DUM( 6, 7)= AK SNL*12.
DUM( 7, 1)= -GX3
DUM( 7, 2)= -GZ3
DUM( 7, 3)= ((-SNLX+ALL*GX3)*GZ3 -(SNLZ+ALL*GZ3)*GX3)/12.
DUM( 7, 7)= -1.
DO 20 I=1,3
DO 20 J=1,3
20 SNUD(I,J)=SNUD(I,J)+DUM(I,6)*ADSNL*DUM(7,-)*12.
CALL MASH( 3,7)
DO 1010 I=1,3
DO 1010 J=1,3
1010 FBOT( I,J)=DUM( I,J)
DO 1011 I=1,3
DO 1011 J=1,3
1011 SNU( I,J)= FTOP( I,J)+FBOT( I,J)
RETURN
1002 DO 1003 I=1,3
DO 1003 J=1,3
SNUD( I,J)=0
1003 SNU( I,J)=0
RETURN
END
SUBROUTINE DRCSN( THETA)
COMMON /DAT/AERO( 150),AEROP( 50),KODE( 20),LL
COMMON /SNUBR/SNU( 3,3),SN( 30),THUSN,THLSN,SNUC( 3,3)
EQUIVALENCE(AERO( 105), SNLX),(AERO( 106), SNLY),(AERC( 107), SNUZ),
1 (AERO( 108), SNLX),(AERO( 109), SNLY),(AERC( 110), SNLZ),CBL 17380
2 (AERO( 111), SNLST),(AERO( 112), SNLVL),(AERC( 113), SNUBL),CBL 17390
3 (AERO( 114), SNLST),(AERO( 115), SNLVL),(AERC( 116), SNLBL),CBL 17400
4 (AERO( 117), TUSNO),(AERC( 118), TLESNC),(AERC( 119), AKSNU),CBL 17410
5 (AERO( 120), AKSNL),CBL 17420
6 (AERO( 76), WLCSR),(AERC( 77), STACR),(AERC( 78), BLCR)CBL 17430
EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1),CBL 17440
1 (SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2),CBL 17450
2 (SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3),CBL 17460
3 (SN( 10), GX4),(SN( 11), GY4),(SN( 12), GZ4),CBL 17470
4 (SN( 13), THU),(SN( 14), THL),(SN( 15), ALU),CBL 17480
5 (SN( 16), ALL),CBL 17490
6 (SN( 19), THGX1),(SN( 20), THGY1),(SN( 21), THGZ1),CBL 17500
7 (SN( 22), THGX2),(SN( 23), THGY2),(SN( 24), THGZ2),CBL 17510
8 (SN( 25), THGX3),(SN( 26), THGY3),(SN( 27), THGZ3),CBL 17520
9 (SN( 28), THGX4),(SN( 29), THGY4),(SN( 30), THGZ4),CBL 17530
C CALCULATION OF SNUBBER CABLE DIRECTION COSINES
XB1= (STACR-SNLST)*COS( THETA)-(WLCSR-SNLVL)*SIN( THETA)CBL 17550
ZR1= (WLCSR-SNUBL)*COS( THETA)+(STACR-SNLST)*SIN( THETA)CBL 17560
XB2= XB1CBL 17570
ZR2= ZR1CBL 17580
XB3= (STACR-SNLST)*COS( THETA)-(WLCSR-SNLVL)*SIN( THETA)CBL 17590
ZR3= (WLCSR-SNLVL)*COS( THETA)+(STACR-SNLST)*SIN( THETA)CBL 17600

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FILE CABLE FORTRAN PI

G F L M P A N DATA SYSTEMS

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XB4= XB3          CBL 17610
ZB4=ZB3          CBL 17620
DX 1= XB1+SNUX   CBL 17630
DY 1= -SNUBL+SNLY CBL 17640
DZ 1= ZB1+SNUZ   CBL 17650
DX 2= DX1         CBL 17660
DY 2= SNUBL-SNUY CBL 17670
DZ 2= DZ1         CBL 17680
DX 3= XB3+SNLX   CBL 17690
DY 3= SNLBL-SNLY CBL 17700
DZ 3= ZB3-SNLZ   CBL 17710
DX 4= DX3         CBL 17720
DY 4= -SNLBL+SNLY CBL 17730
DZ 4= DZ3         CBL 17740
ALUSQ= DX1**2 + DY1**2 + DZ1**2 CBL 17750
ALU = SQRT(ALUSQ) CBL 17760
ALLSQ = DX3**2 + DY3**2 + DZ3**2 CBL 17770
ALL = SQRT(ALLSQ) CBL 17780
GX 1 = DX1/ALU    CBL 17790
GY 1 = DY1/ALU    CBL 17800
GZ 1 = DZ1/ALU    CBL 17810
GX 2 = DX2/ALU    CBL 17820
GY 2 = DY2/ALU    CBL 17830
GZ 2 = DZ2/ALU    CBL 17840
GX 3 = DX3/ALL    CBL 17850
GY 3 = DY3/ALL    CBL 17860
GZ 3 = DZ3/ALL    CBL 17870
GX 4 = DX4/ALL    CBL 17880
GY 4 = DY4/ALL    CBL 17890
GZ 4 = DZ4/ALL    CBL 17900
DO 1 I=19,20      CBL 17910
J=I-18            CBL 17920
1 SN(I)=ARCCOS(SN(J)) CBL 17930
RETURN            CBL 17940
END               CBL 17950
SUBROUTINE DRCLSN(THETA) CBL 17960
COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL CBL 17970
COMMON/SNURB/SNL(3,3),SN(30),THLSN,THLSN,SNLC(3,3) CBL 17980
EQUIVALENCE(AERO(105), SNLX),(AERO(106), SNLY),(AERO(107), SNUZ), CBL 17990
1 (AERO(108), SNLX),(AERO(109), SNLY),(AERC(110), SNLZ),CBL 18000
2 (AERO(111),SNLST),(AERO(112),SNUBL),(AERC(113),SNUBL),CBL 18010
3 (AERO(114),SNLST),(AERO(115),SNUBL),(AEFC(116),SNLBL),CBL 18020
4 (AERO(117),TUSNO),(AERO(118),TLSNC),(AERC(119),AKSNU),CBL 18030
5 (AERO(120),AKSNL), CBL 18040
6 (AERO(76),WLCR),(AERO(77),STACF),(AEFC(78),BLCR) CBL 18050
EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1), CBL 18060
1 (SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2), CBL 18070
2 (SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3), CBL 18080
3 (SN(10), GX4),(SN(11), GY4),(SN(12), GZ4), CBL 18090
4 (SN(13), THU),(SN(14), THL),(SN(15), ALU), CBL 18100
5 (SN(16), ALL), CBL 18110
6 (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1), CBL 18120
7 (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2), CBL 18130
8 (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3), CBL 18140
9 (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4) CBL 18150

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FILE CABLE FORTRAN PI

G F U N K A N D A T A S Y S T E M S

C CALCULATION FOR EFFECTIVE DIRECTION COSINES FOR UNSUBED CASE CBL 18160
AYL = SNLBL-(BLCR+SNLY) CBL 18170
AZL = -SNLWL-(WLCR+SNLZ+SNLX*SIN(THETA)) CBL 18180
AYU = SNURL-(RLCR+SNUY) CBL 18190
AZU = SNUWL-(WLCR+SNUZ-SNLX*SIN(THETA)) CBL 18200
THU = ATAN(AZU/AYU) CBL 18210
THL = ATAN(AZL/AYL) CBL 18220
ALU = AYU/(SIN(THUSN)*COS(THL)) CBL 18230
GX1S = -COS(THUSN) CBL 18240
GY1S = -AYU/ALU CBL 18250
GZ1S = -AZU/ALU CBL 18260
GX1 = GX1S*COS(THETA)-GZ1S*SIN(THETA) CBL 18270
GY1 = GY1S CBL 18280
GZ1 = GZ1S*COS(THETA)+GX1S*SIN(THETA) CBL 18290
GX2 = GX1 CBL 18300
GY2 = -GY1 CBL 18310
GZ2 = GZ1 CBL 18320
ALL = AYL/(SIN(THUSN)*COS(THL)) CBL 18330
GX3S = -COS(THUSN) CBL 18340
GY3S = AYL/ALL CBL 18350
GZ3S = AZL/ALL CBL 18360
GX3 = GX3S*COS(THETA)-GZ3S*SIN(THETA) CBL 18370
GY3 = GY3S CBL 18380
GZ3 = GZ3S*COS(THETA)+GX3S*SIN(THETA) CBL 18390
GX4 = GX3 CBL 18400
GY4 = -GY3 CBL 18410
GZ4 = GZ3 CBL 18420
DO 1 I=19,30 CBL 18430
J=T-18 CBL 18440
1 SN(I)=ARCCOS(SN(J)) CBL 18450
RETURN CBL 18460
END CBL 18470
SUBROUTINE RITE CBL 18480
COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL CBL 18490
IW=6 CBL 18500
IF(KODE(6).GT.1) GO TO 1 CBL 18510
WRITE(IW,100) CBL 18520
100 FORMAT(15X,'FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL') CBL 18530
GO TO 4 CBL 18540
1 IF(KODE(6).GT.2) GO TO 2 CBL 18550
WRITE(IW,200) CBL 18560
200 FORMAT(15X,'FRONT CABLE HORIZONTAL, REAR CABLE VERTICAL') CBL 18570
GO TO 4 CBL 18580
2 IF(KODE(6).GT.3) GO TO 3 CBL 18590
WRITE(IW,300) CBL 18600
300 FORMAT(15X,'BOTH CABLES VERTICAL') CBL 18610
GO TO 4 CBL 18620
3 WRITE(IW,400) CBL 18630
400 FORMAT(15X,'BOTH CABLES HORIZONTAL') CBL 18640
4 CONTINUE CBL 18650
IF(KODE(10).EQ.0) GO TO 5 CBL 18660
IF(KODE(10).EQ.1) GO TO 6 CBL 18670
WRITE(IW,500) CBL 18680
5 FORMAT(15X,'SNUBBERS SNUBBED') CBL 18690
GO TO 7 CBL 18700

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5 WRITE( IW, ECC)
0 FORMAT( 15X, "NO SNUBBERS")
GO TO 7
6 WRITE( IW, 700)
700 FORMAT( 15X, "SNUBBERS UNSNUBBED")
7 CONTINUE
IF(KODE( 11).EQ.0) GO TO 8
WRITE( IW, 800)
800 FORMAT( 15X, "LIFT/ANTI-LIFT CABLE IN")
GO TO 9
9 WRITE( IW, 900)
900 FORMAT( 15X, "NO LIFT/ANTI-LIFT CABLE")
9 CONTINUE
RETURN
END
SUBROUTINE STINT(A1,A2,A3,MINTBL,MAXTBL,FCT,NG)
EQUIVALENCE (X( 1),NUMPTS( 1))
COMMON NUMPTS( 1)
DIMENSION X( 1)
IZ=NUMPTS( 1)/3
70 IF(MINTBL-MAXTBL)71,71,110
71 DO 73 II=MINTBL,MAXTBL
NJ=NUMPTS( II)+1
IF(A3-X( NJ))72,74,73
72 IF( II-MINTBL) 110,112,75
73 CONTINUE
GO TO 112
5 IK = 1
IL =2
NM=NJ
101 DO 97 IF=IK,IL
NJ =NUMPTS( II)+1
NI = IZ+II
IO =NUMPTS(NI)
IP =IO +NJ
DO 77 IQ=1,IO
NN = NJ +IQ
IF (A1-X(NN))76,78,77
76 IF( IQ-1) 110,112,79
77 CONTINUE
GO TO 112
78 IG =-1
GO TO 80
79 IG =+1
80 NI=NI+IZ
IB = NUMPTS(NI)
DO 82 IA=1,IB
NS=IP+IA
IF (A2-X(NS))81,83,82
81 IF( IA-1) 110,112,84
82 CONTINUE
GO TO 112
3 IH =-1
GO TO 85
84 IH =+1

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CBL 18710
CBL 18720
CBL 18730
CBL 18740
CBL 18750
CBL 18760
CBL 18770
CBL 18780
CBL 18790
CBL 18800
CBL 18810
CBL 18820
CBL 18830
CBL 18840
CBL 18850
CBL 18860
CBL 18870
CBL 18880
CBL 18890
CBL 18900
CBL 18910
CBL 18920
CBL 18930
CBL 18940
CBL 18950
CBL 18960
CBL 18970
CBL 18980
CBL 18990
CBL 19000
CBL 19010
CBL 19020
CBL 19030
CBL 19040
CBL 19050
CBL 19060
CBL 19070
CBL 19080
CBL 19090
CBL 19100
CBL 19110
CBL 19120
CBL 19130
CBL 19140
CBL 19150
CBL 19160
CBL 19170
CBL 19180
CBL 19190
CBL 19200
CBL 19210
CBL 19220
CBL 19230
CBL 19240
CBL 19250

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85 NE=IP+IB+IQ+IO*IA-IO          CBL19260
NR=NE-IO                         CBL19270
IF(IG+IH) E6,88,91               CBL19280
86 IF(X(NE)-9999E.5E9)87,113,113 CBL19290
87 FCT = X(NE)                   CBL19300
GO TO 95                          CBL19310
88 IF(IG) 89,110,53               CBL19320
89 IF(AMAX1(X(NE),X(NR))-99998.5E9)90,113,113 CBL19330
90 FCT = X(NE)-(X(NS)-A2)*(X(NE)-X(NR))/(X(NS)-X(NS-1)) CBL19340
GO TO 95                          CBL19350
91 IF(AMAX1(X(NE),X(NR),X(NE-1),X(NR-1))-99998.5E9)92,113,113 CBL19360
92 FCT = ((X(NS)-A2)*((X(NN)-A1)*X(NR-1)-(X(NN-1)-A1)*X(NR)) . CBL19370
1)-(X(NS-1)-A2)*((X(NN)-A1)*X(NE-1)-(X(NN-1)-A1)*X(NE))) CBL19380
2/((X(NS)-X(NS-1))*(X(NN)-X(NN-1))) CBL19390
GO TO 95                          CBL19400
93 IF(AMAX1( X(NE), X(NE-1))-99998.5E9) 94,113,113 CBL19410
94 FCT = X(NE)-( X(NN)-A1)*( X(NE)- X(NE-1))/( X(NN)- X(NN-1)) CBL19420
95 GO TO (96,98,99).IF            CBL19430
96 DUMSTG=FCT                   CBL19440
97 II =II-1                      CBL19450
98 FCT =DUMSTG-( X(NM)-A3)*(DUMSTG-FCT)/( X(NN)- X(NJ)) CBL19460
99 RETURN                         CBL19470
74 IK =3                         CBL19480
IL =3                           CBL19490
GO TO 101                        CBL19500
110 NG =2                         CBL19510
GO TO 99                          CBL19520
2 NG =3                         CBL19530
GO TO 99                          CBL19540
113 NG =4                         CBL19550
GO TO 99                          CBL19560
END
SUBROUTINE TABIN(NUMTBL,NZ,NG)
COMMON NUMPTS(1)                  CBL19570
COMMON /TABOUT/ NIMTBL,ISQ
DIMENSION XUMPTS(1)                CBL19580
INTEGER*2 LABEL(27)                CBL19590
EQUIVALENCE (XUMPTS(1),NUMPTS(1)),(DUMMY(1),NUMY)
DIMENSION DUMMY(10)                CBL19600
MCR=0                            CBL19610
10 IZ=IABS(NZ)                   CBL19620
NUNIT=5                          CBL19630
IF(NZ.LT.0) NUNIT=8               CBL19640
NIMTBL = NUMTBL                  CBL19650
NG=0                             CBL19660
NUMPTS(1)=IZ+IZ+IZ               CBL19670
102 READ(NUNIT,67) K, LIN, L2N, LABEL, ISEC
IF(MCR.EQ.0) GO TO 3             CBL19680
4 WRITE(6,1) K,LIN,L2N,LABEL,ISEQ
1 FORMAT(3I5, 1CX,27A2,I46)      CBL19690
57 FORMAT(8XI4.2I2,27A2,I2)       CBL19700
3 IF(ISEQ) E6,5E,69               CBL19710
7 IF(K) 99, 99, 99                CBL19720
9 M = IZ + NIMTBL                CBL19730
NUMPTS(M) = LIN                  CBL19740

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FILE CABLE FORTRAN P1

G F U N P A R DATA S Y S T E M S

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M = M + IZ                                CBL 19810
NUMPTS(M) = L2N                             CBL 19820
IF(NUMTBL-NIMTBL)17,70,17                  CBL 19830
17 NUMPTS(NIMTBL) = MUMMY                 CBL 19840
70 N1 = (L1N-1) / S + 1                   CBL 19850
DO 62 IS = 1,N1                           CBL 19860
L3 = (IS-1) * S + 1                      CBL 19870
IF (IS-N1) 60, E1, 60                     CBL 19880
60 L4 = L3 + E                           CBL 19890
GO TO 62                                 CBL 19900
61 L4 = L1N                               CBL 19910
62 L5 = NUMPTS(NIMTBL) + 1                CBL 19920
L6 = L5 + L3                            CBL 19930
L7 = L5 + L4                            CBL 19940
JJ = 0                                  CBL 19950
LM = L5 + L1N                           CBL 19960
LN = LM + L2N                           CBL 19970
63 READ(NUINT,64) (DUMMY(K),K=1+1C) . ISEQ
64 FORMAT (10E7.0,I2)
IF(MCR.EQ.C) GO TO 5
6 WRITE(6,2)DUMMY,ISEQ
2 FORMAT(10E12.4,I5)
5 XUMPTS(L5)= DUMMY(1)
K = 2
DO 65 J = L6,L7
XUMPTS(J) = DUMMY(K)
65 K = K+1
ISOQ=(IS-1)*(L2N+1)+JJ+1
IF(ISEQ-ISOQ) E9,E6,69
66 L6 = LN + L3
L7 = LN + L4
L5 = LM + 1 + JJ
IF (JJ-L2N) 67, E8, 69
67 JJ = JJ + 1
LN = LN + L1N
GO TO E3
68 CONTINUE
109 MUMMY = NUMPTS(NIMTBL) + (L1N+1) * (L2N+1)
109 NIMTBL = NIMTBL + 1
GO TO 102
69 NG = 1
99 RETURN
END
SUBROUTINE STINT1(A1,A2,A3,MINTBL,MAXTBL,FCT,NG)
EQUIVALENCE (X(1),NUMPTS(1))
COMMON/TAB1/NUMPTS(1)
DIMENSION X(1)
IZ=NUMPTS(1)/3
70 IF(MINTBL-MAXTBL)71,71,110
71 DO 72 II=MINTBL,MAXTBL
NJ=NUMPTS(II)+1
IF(A3-X(NJ))72,74,73
72 IF(II-MINTBL) 110,112,75
73 CONTINUE
GO TO 112
```

FILE CABLE FORTRAN PI

G F L M R A N D A T A S Y S T E M S

```
75 IK = 1                                CBL 20360
    IL = 2                                CBL 20370
    NM=NJ                                 CBL 20380
101 DO 97 IF=IK,IL                         CBL 20390
    NJ =NUMPTS(I1)+1                      CBL 20400
    NI = IZ+II                            CBL 20410
    IO =NUMPTS(NI)                        CBL 20420
    IP =IO+NJ                            CBL 20430
    DO 77 IQ=1,IO                         CBL 20440
    NN = NJ+IQ                           CBL 20450
    IF (A1-X(NN))76,7E,77                CBL 20460
76 IF( IQ-1) 110,112,79                  CBL 20470
77 CONTINUE                               CBL 20480
    GO TO 112                            CBL 20490
78 IG =-1                                 CBL 20500
    GO TO 80                            CBL 20510
79 IG =+1                                 CBL 20520
80 NI=NI+IZ                            CBL 20530
    IR = NUMPTS(NI)                      CBL 20540
    DO 82 IA=1,IR                         CBL 20550
    NS=IP+IA                            CBL 20560
    IF (A2-X(NS))81,E3,E2                CBL 20570
81 IF( IA-1) 110,112,84                  CBL 20580
82 CONTINUE                               CBL 20590
    GO TO 112                            CBL 20600
83 IH =-1                                 CBL 20610
    GO TO 85                            CBL 20620
 4 IH =+1                                 CBL 20630
85 NE=IP+IB+IQ+IO*IA-IO                 CBL 20640
    NR=NE-IO                            CBL 20650
    IF( IC+IH) E6,BE,S1                CBL 20660
86 IF (X(NE)-5555E.EE9)87,113,113      CBL 20670
87 FCT = X(NE)                            CBL 20680
    GO TO 95                            CBL 20690
88 IF( IC) 89,110,S3                  CBL 20700
89 IF( AMAX1(X(NE),X(NR))-99998.5E9)90,113,113  CBL 20710
90 FCT = X(NE)-(X(NS)-A2)*(X(NE)-X(NR))/(X(NS)-X(NS-1)) CBL 20720
    GO TO 95                            CBL 20730
91 IF( AMAX1(X(NE),X(NR),X(NE-1),X(NR-1))-9999E.5E9)92,113,113  CBL 20740
92 FCT = ((X(NS)-A2)*((X(NN)-A1)*X(NR-1)-(X(NN-1)-A1)*X(NR) CBL 20750
    1)-(X(NS-1)-A2)*((X(NN)-A1)*X(NE-1)-(X(NN-1)-A1)*X(NE))) CBL 20760
    2/((X(NS)-X(NS-1))*(X(NN)-X(NN-1))) CBL 20770
    GO TO 95                            CBL 20780
93 IF( AMAX1( X(NE), X(NE-1))-99998.5E9) 94,113,113  CBL 20790
94 FCT = X(NE)-( X(NN)-A1)*( X(NE)- X(NE-1))/(( X(NN)- X(NN-1)) CBL 20800
95 GO TO (S6,S8,S9),IF                  CBL 20810
96 DUMSTG =FCT                          CBL 20820
97 II =II-1                            CBL 20830
98 FCT =DUMSTG-( X(NM)-A3)*(DUMSTG-FCT)/( X(NM)- X(NJ)) CBL 20840
99 RETURN                                CBL 20850
74 IK =3                                CBL 20860
    IL =3                                CBL 20870
    GO TO 101                            CBL 20880
0 NG =2                                CBL 20890
    GO TO 99                            CBL 20900
```

```

112 NG =3
    GO TO 99
3 NG =4
    GO TO 99
END
SUBROUTINE TABIN1(NLMTBL,NZ,NG)
COMMON/TAB1/NUMPTS(1)
COMMON /TABOU1/ NIMTBL,IS0Q
DIMENSION XUMPTS(1)
INTEGER*2 LABEL(27)
EQUIVALENCE (XUMPTS(1),NUMPTS(1)),(DUMMY(1),NMUMMY)
DIMENSION DUMMY(10)
MCR=C
10 IZ=IABS(NZ)
NUNIT=5
IF(NZ.LT.0) NUNIT=8
NIMTBL = NLMTBL
NG=0
NJMPTS(1)=IZ+IZ+IZ
102 READ(NUNIT,57) K, LIN, L2N, LABEL, ISEC
    IF(MCR.EQ.C) GO TO 3
4 WRITE(6,1) K,LIN,L2N,LABEL,ISEC
1 FORMAT(3I5, 10X,27A2,I4)
57 FORMAT(Ex14.2I2,27A2,I2)
3 IF(ISEQ) 69,5E,69
58 IF(K) 99, 99, 99
59 M = IZ + NIMTBL
NJMPTS(M) = LIN
60 M = M + IZ
NJMPTS(M) = L2N
IF(NUMTBL-NIMTBL)17,70,17
17 NUMPTS(NIMTBL) = NMUMMY
70 N1 = (LIN-1) / 9 + 1
DO 68 IS = 1,N1
L3 = (IS-1) * 9 + 1
IF ((IS-N1) .EQ. 1) 60, 61, 60
60 L4 = L3 + F
GO TO 62
61 L4 = LIN
62 L5 = NUMPTS(NIMTBL) + 1
L6 = L5 + L3
L7 = L6 + L4
JJ = 0
LM = L5 + LIN
LN = LM + L2N
63 READ(NUNIT,64) (DUMMY(K),K=1,10), ISEC
64 FORMAT (10E7.0,I2)
IF(MCR.EQ.0) GO TO 5
6 WRITE(6,2)DUMMY,ISEQ
2 FORMAT(10E12.4,I5)
5 XUMPTS(L5)= DUMMY(1)
K = 2
DO 65 J = L6,L7
XUMPTS(J) = DUMMY(K)
65 K = K+1

```

FILE CABLE FORTRAN PI

G R U N D A N D A T A S Y S T E M S

```
ISOQ=( IS-1)*(L2N+1)+JJ+1          CBL 21460
IF( ISEQ-ISOQ ) 69,EE,69          CBL 21470
L6 = LN + L3                      CBL 21480
L7 = LN + L4                      CBL 21490
L5 = LM + 1 + JJ                  CBL 21500
IF (JJ-L2N) 67, EE, 69          CBL 21510
67  JJ = JJ + 1                  CBL 21520
LN = LN + LIN                     CBL 21530
GO TO 63                          CBL 21540
68  CONTINUE                      CBL 21550
109 MUMMY = NUMPTS(NIMTBL) + (LIN+1) * (L2N+1)    CBL 21560
108 NIMTAL = NIMTBL + 1           CBL 21570
GO TO 102                         CBL 21580
69  NG = 1                         CBL 21590
99  RETURN                         CBL 21600
END                               CBL 21610
SUBROUTINE FRIC(TIDX)
COMMON/DAT/AERO(150),AEROP(50),KODE(20)
COMMON/ROUGH/FRIC(3,6)
EQUIVALENCE (AERO(96),COU),(AERO(104),CMF)
DO 1 I=1,3
DO 1 J=1,6
1 FRIC(I,J)=0.
IF(CMP.EQ.0..AND.COUEQ.0.)RETURN
IND=KODE(6)
IF( IDX.NE.0)GO TO 2
C - LONGITUDINAL PULLEY FRICTION COMPUTATION
GO TO( 10,11,12,13),IND
10 CALL FRVT(1)
RETURN
11 CALL FRVT(3)
RETURN
12 CALL FRVT(1)
CALL FRVT(3)
13 RETURN
C - LATERAL DIRECTIONAL FRICTION COMPUTATION
2 GO TO( 20,21,22,23),IND
20 CALL FRHZ(3)
RETURN
21 CALL FRHZ(1)
22 RETURN
23 CALL FRHZ(1)
CALL FRHZ(3)
RETURN
END
SUBROUTINE FRVT(IC)
C - COMPUTES THE FRIC. EFFECT OF THE VERT PULLEYS ON THE LONG. DYN.
COMMON/DAT/AERO(150),AEROP(50),KODE(20)
COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF
COMMON/ROUGH/FRIC(3,6)
EQUIVALENCE (AERO(9C),RVF),(AERO(92),RVF),(AEFC(96),CCU),
1(AERO(104),CMP)
DIMENSION DT1(3),DT2(3)
IF( IC.EQ.3)GO TO 1
TENS=TF
CBL 21920
CBL 21930
CBL 21940
CBL 21950
CBL 21960
CBL 21970
CBL 21980
CBL 21990
CBL 22000
```

FILE CABLE FORTRAN P1

G F U N D A N D A T A S Y S T E M S

```
RAD=RVF/12.  
AVX=(ADC(2,1)-ADC(1,1))/2.  
CAX=COS(AVX)  
CAZ=SIN(AVX)  
GO TO 2  
1 TENS=TR  
RAD=RVR/12.  
AVX=3.14159*(ADC(4,1)-ADC(3,1))/2.  
CAX=COS(AVX)  
CAZ=SIN(AVX)  
2 ARMX=(ARM(1C,1)+ARM(1C+1,1))/24.  
ARMZ=(ARM(1C+1,3)-ARM(1C,3))/24.  
ENORX=TENS*COS(ADC(1C,1))  
ENORZ=TENS*(1.+COS(ADC(1C,3)))  
ENORM=SQRT(ENORX**2+ENORZ**2)  
CMPP=CMPP/ENORM  
FACU=CMPP*ENORM/RAD**2  
ENORX=TENS*COS(ADC(1C+1,1))  
ENORZ=TENS*(1.+COS(ADC(1C+1,3)))  
ENORM=SQRT(ENORX**2+ENORZ**2)  
CMPP=CMPP/ENORM  
FACT=CMPP*ENORM/RAD**2  
FACT=4.*COU/(3.14159*RAD**2)  
CALL DLGTH(CX,CZ,CT,IC,0)  
CALL DLGTH(CXP,CZP,CTP,IC+1,0)  
DT1(1)=FACT*(CXP-CX)  
DT1(2)=FACT*(CZP-CZ)  
DT1(3)=FACT*(CTP-CT)  
DT2(1)=FACT*CXP-FACU*CX  
DT2(2)=FACT*CZP-FACU*CZ  
DT2(3)=FACT*CTP-FACU*CT  
DO 3 I=1,3  
FR IC(1,I)=FR IC(1,I)+DT1(I)*CAX  
FR IC(1,I+3)=FR IC(1,I+3)+DT2(I)*CAX  
FR IC(2,I)=FR IC(2,I)+DT1(I)*CAZ  
FR IC(2,I+3)=FR IC(2,I+3)+DT2(I)*CAZ  
FR IC(3,I)=FR IC(3,I)+DT1(I)*RAD+DT1(I)*CAX*AFNZ-CT1(I)*CAZ*ARMX  
FR IC(3,I+3)=FR IC(3,I+3)+DT2(I)*RAD+DT2(I)*CAX*AFNZ-CT2(I)*CAZ*ARMX  
3 CONTINUE  
RETURN  
END  
SUBROUTINE FRHZ(IC)  
C COMPUTES THE FRICT. EFFECT OF THE HORZ PULLEYS ON THE LAT. DIR. DYN.  
COMMON/DAT/AERO(150),AEROP(50),KODE(20)  
COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF  
COMMON/ROUGH/FRIC(3,6)  
EQUIVALENCE (AERO(91),RHF),(AERO(93),RHF),(AEFC(96),COU),  
1(AERO(104),CMP)  
DIMENSION DT1(3),DT2(3)  
IF( IC.EQ.3)GO TO 1  
TENS=TF  
RAD=RHF/12.  
GO TO 2  
1 TENS=TR  
RAD=RHR/12.  
CBL 22010  
CBL 22020  
CBL 22030  
CBL 22040  
CBL 22050  
CBL 22060  
CBL 22070  
CBL 22080  
CBL 22090  
CBL 22100  
CBL 22110  
CBL 22120  
CBL 22130  
CBL 22140  
CBL 22150  
CBL 22160  
CBL 22170  
CBL 22180  
CBL 22190  
CBL 22200  
CBL 22210  
CBL 22220  
CBL 22230  
CBL 22240  
CBL 22250  
CBL 22260  
CBL 22270  
CBL 22280  
CBL 22290  
CBL 22300  
CBL 22310  
CBL 22320  
CBL 22330  
CBL 22340  
CBL 22350  
CBL 22360  
CBL 22370  
CBL 22380  
CBL 22390  
CBL 22400  
CBL 22410  
CBL 22420  
CBL 22430  
CBL 22440  
CBL 22450  
CBL 22460  
CBL 22470  
CBL 22480  
CBL 22490  
CBL 22500  
CBL 22510  
CBL 22520  
CBL 22530  
CBL 22540  
CBL 22550
```

```

2 ENORX=TENS*COS(ADC(IC,1))
ENORY=TENS*(1.+COS(ADC(IC,2)))
ENORM=SQRT(ENORY*ENORY+ENORX*ENORX)
CMPP=CMPP/ENORM
FACT=CMPP*ENORM/RAD**2
FACT=4.*COL/(3.14159*RAD**2)
CALL DLGTH(CY,CPSI,CPHI,IC,1)
CALL DLGTH(CYP,CPSIP,CPHIP,IC+1,1)
DT1(1)=FACT*(CY-CYP)
DT1(2)=FACT*(CPSI-CPSIP)
DT1(3)=FACT*(CPHI-CPHIP)
DT2(1)=FACT*(CY-CYP)
DT2(2)=FACT*(CPSI-CPSIP)
DT2(3)=FACT*(CPHI-CPHIP)
DO 3 I=1,3
FR IC(1,I)=FR IC(1,I)+DT1(I)*COS(ADC(IC,2))
FR IC(1,I+3)=FR IC(1,I+3)+DT2(I)*COS(ADC(IC,2))
FR IC(2,I)=FR IC(2,I)+DT1(I)*RAD-DT1(I)*CCS(ACC(IC,1))*ARM(IC,2)
1/12.+DT1(I)*COS(ADC(IC,2))*ARM(IC,1)/12.
FR IC(2,I+3)=FR IC(2,I+3)+DT2(I)*RAD-DT2(I)*CCS(ACC(IC,1))*ARM(IC,2)
1/12.+DT2(I)*COS(ADC(IC,2))*ARM(IC,1)/12.
FR IC(3,I)=FR IC(3,I)+DT1(I)*RAD+DT1(I)*CCS(ACC(IC,3))*ARM(IC,2)
1/12.-ARM(IC,3)/12.*DT1(I)*COS(ADC(IC,2))
FR IC(3,I+3)=FR IC(3,I+3)+DT2(I)*RAD+DT2(I)*CCS(ACC(IC,3))*ARM(IC,2)
1/12.-ARM(IC,3)/12.*DT2(I)*COS(ADC(IC,2))
3 CONTINUE
RETURN
END

C~THIS IS A SINGLE PRECISION VERSION OF THE LRC MATRIX
C MATRIX REDUCTION AND THE IBM ROOT FINDING ROUTINE
SUBROUTINE MATRIX(A,N,ROOTS,K4A,IER)
COMPLFX ROOTS(1)
DIMENSION A(7,7,3),ATILDA(7,7,15),ADET(29),
1 G(7,7,15)
DIMENSION COEF(29),EQ(29),RR(29),RC(29),FCL(29)
COMMON /DATA/AERO(150),AEROP(50),KODE(20),LL
DO 501 I=1,29
501 ADET(I)=0
ISWCK=1
IW=6
K=2
KP1 = K + 1
IF(KODE(5).EQ.0) GO TO 26
DO 25 I = 1, N
DO 25 J = 1, N
WRITE(IW, 39) I, J
25 WRITE(IW, 50) (A(I,J,K1), K1 = 1, KP1)
26 CALL SCALER(A,1..N,N,KP1)
CALL EQUIIL(A,N,N,KP1,EQ,DDET)
CALL ENVERT(N, A, K, G, ATILDA, ADET)
DO 301 I=1,29
301 COEF(I)=ADET(I)
DO 27 I=1,29
27 IF(ARS(COEF(I)).LT.1.E-08) COEF(I)=0.
IF(KODE(5).EQ.0) GO TO 305

```

```

WR ITE( IW, 4C1)                               CBL 23110
101 FORMAT(2X, *COEFFICIENTS OF CHARACTERISTIC POLYNOMIAL
   ORDERED FROM LOW TO HIGH*)
   WR ITE( IW, 4CC)(COEF(I),I=1,29)
400 FFORMAT(6(2X,E10.3))
305 CONTINUE
   CALL PRBM1(COEF,29,RR,RC,PCL,IRT,IER,50)
   DO 300 I=1,IRT
300 ROOTS(I)=CMPLX(RR(I),RC(I))
   K4A=IRT
   RETURN
39 FORMAT(2EX, 3HA (, I2, 1H,, I2, 1H))
50 FORMAT (6E19.6)
   END

SUBROUTINE POLADD(N1,V1,N2,V2,N3,V3)
C SUM OF TWO POLYNOMIALS
C
C N1= DEGREE OF P1 (FIRST POLYNOMIAL)
C N2= DEGREE OF P2
C N3= DEGREE OF OUTPUT POLYNOMIAL
C
C V1= BASE ADDRESS OF COEFFICIENTS OF P1
C V2= BASE ADDRESS OF COEFFICIENTS OF P2
C V3= BASE ADDRESS OF OUTPUT VECTOR.
C
C THIS ROUTINE WILL HANDLE A POLYNOMIAL OF DEGREE 50
DIMENSION V1(51),V2(51),V3(51)
C
C - PERFORM ADD --ADD COEFFICIENTS OF LIKE TERMS
IC3=N2+1
IC1=N1+1
IC2=N2+2
IC4=N1+2
IF (N2-N1) 1,8,2
1  DO 4 I=IC2,IC1
4  V3(I)=V1(I)
8  N3= N1
   DO 5 I=1,IC3
5  V3(I)= V1(I)+V2(I)
   RETURN
2  N3 = N2
   DO 6 I=1,IC1
6  V3(I)=V1(I)+V2(I)
   CONTINUE
   DO 7 J=IC4,IC3
7  V3(J)=V2(J)
   CONTINUE
   RETURN
END
SUBROUTINE POLSUB (N1,V1,N2,V2,N3,V3)
C
C SUBTRACT P2 FROM P1 AND STORE IN P3
C
C SEE NOTES ON ADD
DIMENSION V1(51),V2(51),V3(51)

```

FILE CABLE FORTRAN P1

G F U N K M A N D A T A S Y S T E M S

```
IC1=N1+1                                CBL 23660
IC2=N2+1                                CBL 23670
IC3=N2+2                                CBL 23680
IC4=N1+2                                CBL 23690
IF (N2-N1) 1.8,2                          CBL 23700
1   DO 4 I= IC3,IC1                      CBL 23710
4   V3(I) = V1(I)
8   N3=N1                                CBL 23720
     DO 5 I=1,IC2                        CBL 23730
5   V3(I)=V1(I)-V2(I)
     RETURN                               CBL 23740
2   N3=N2                                CBL 23750
     DO 6 I=1,IC1                        CBL 23760
6   V3(I)=V1(I)-V2(I)
     CONTINUE                            CBL 23770
     DO 7 J=IC4,IC2                      CBL 23780
7   V3(J)=-V2(J)
     CONTINUE                            CBL 23790
     RETURN                               CBL 23800
     END                                  CBL 23810
                                         CBL 23820
                                         CBL 23830
                                         CBL 23840
                                         CBL 23850
                                         CBL 23860
                                         CBL 23870
                                         CBL 23880
                                         CBL 23890
                                         CBL 23900
                                         CBL 23910
                                         CBL 23920
                                         CBL 23930
                                         CBL 23940
                                         CBL 23950
                                         CBL 23960
                                         CBL 23970
                                         CBL 23980
                                         CBL 23990
                                         CBL 24000
                                         CBL 24010
                                         CBL 24020
                                         CBL 24030
                                         CBL 24040
                                         CBL 24050
                                         CBL 24060
                                         CBL 24070
                                         CBL 24080
                                         CBL 24090
                                         CBL 24100
                                         CBL 24110
                                         CBL 24120
                                         CBL 24130
                                         CBL 24140
                                         CBL 24150
                                         CBL 24160
                                         CBL 24170
                                         CBL 24180
                                         CBL 24190
                                         CBL 24200

SUBROUTINE POLMPY(N1,START1,N2,START2,N3,START3)
C MULTIPLY TWO POLYNOMIALS
C N1 = DEGREE OF P1 (THE FIRST POLYNOMIAL)
C N2 = DEGREE OF P2
C N3 = THE LOCATION (INT.) WHERE THE DEGREE OF THE OUTPUT
C      POLYNOMIAL WILL BE STORED.
C START1 = THE FIRST LOCATION OF THE COEFFICIENTS OF P1 . CONSTANT
C          TERM IS FIRST
C START2 = THE FIRST LOCATION OF THE COEFFICIENTS OF P2
C
C START3 = THE BASE LOCATION OF THE OUTPUT POLYNOMIAL
C
C THE ROUTINE WILL HANDLE POLYNOMIALS OF 50TH DEGREE
DIMENSION START1(55),START2(55),START3(55),WCFK(51)
C
C START MULTIPLY -- ZERO OUTPUT VECTOR
C
N4=N1+N2+1
DO 1 I=1,N4
WORK(I) = C.0
1 CONTINUE
C
C CARRY THROUGH MULTIPLICATION PROCESS
C
IC1 = N1+1
IC2 = N2+1
DO 3 I=1,IC1
DO 2 J=1,IC2
WORK(I+J-1) =(START1(I)*START2(J))+WCFK(I+J-1)
2 CONTINUE
3 CONTINUE
DO 4 I=1,N4
START3(I) = WORK(I)
4 N3=N4-1
```

```

RETURN                               CBL 24210
END                                CBL 24220
CBL 24230
CBL 24240
CBL 24250
CBL 24260
CBL 24270
CBL 24280
CBL 24290
CBL 24300
CBL 24310
CBL 24320
CBL 24330
CBL 24340
CBL 24350
CBL 24360
CBL 24370
CBL 24380
CBL 24390
CBL 24400
CBL 24410
CBL 24420
CBL 24430
CBL 24440
CBL 24450
CBL 24460
CBL 24470
CBL 24480
CBL 24490
CBL 24500
CBL 24510
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CBL 24530
CBL 24540
CBL 24550
CBL 24560
CBL 24570
CBL 24580
CBL 24590
CBL 24600
CBL 24610
CBL 24620
CBL 24630
CBL 24640
CBL 24650
CBL 24660
CBL 24670
CBL 24680
CBL 24690
CBL 24700
CBL 24710
CBL 24720
CBL 24730
CBL 24740
CBL 24750

SUBROUTINE MATMPY(A, N, IADEG, B, M, IBDEG, C, NA, NE, NC)
DIMENSION A(7,7,NA),B(7,7,NB),C(7,7,NC),VA(29),VB(29),VC(29)
1      ,VD(29)
IADEG1 = IADEG + 1
IBDEG1 = IBDEG + 1
ICDEG1 = IADEG + IBDEG + 1
DO 10 I = 1, N
DO 10 J = 1, M
DO 50 K = 1, ICDEG1
50 VD(K) = 0.0
DO 20 JJ = 1, N
DO 30 K = 1, IADEG1
30 VA(K) = A(I,JJ,K)
DO 40 K = 1, IBDEG1
40 VB(K) = B(JJ,J,K)
CALL POLMPY(IADEG, VA, IBDEG, VB, ICDEG, VC)
20 CALL POLADD(ICDEG, VC, ICDEG, VD, ICDEG, VC)
DO 60 K = 1, ICDEG1
60 C(I,J,K) = VD(K)
10 CONTINUE
RETURN
END

SUBROUTINE TRACE(N, AI, IADEG, RL, F)
DIMENSION AI(7,7,15),P(27),VA(27),VB(27)
IADEG1 = IADEG + 1
DO 50 K = 1, IADEG1
50 VB(K) = 0.0
DO 10 I = 1, N
DO 20 K = 1, IADEG1
20 VA(K) = AI(I,I,K)
10 CALL POLADD(IADEG, VA, IADEG, VB, IADEG, VE)
DO 30 K = 1, IADEG1
30 P(K) = VB(K) / RL
RETURN
END

SUBROUTINE COMPRI(N, IADEG, AI, P, BI)
DIMENSION AI(7,7,15),BI(7,7,15),P(27),VA(27),VE(27)
IADEG1 = IADEG + 1
DO 10 I = 1, N
DO 10 J = 1, N
IF (I .NE. J) GO TO 20
DO 50 K = 1, IADEG1
50 VA(K) = AI(I,J,K)
CALL POLSUB(IADEG, VA, IADEG, F, IADEG, VE)
DO 51 K = 1, IADEG1
51 BI(I,J,K) = VR(K)
GO TO 10
20 DO 52 K = 1, IADEG1
52 BI(I,J,K) = AI(I,J,K)
10 CONTINUE

```

FILE CABLE FOR TRAN P 1

G F U N K A N DATA SYSTEMS

```

      RETURN          CBL 24760
      END            CBL 24770
                  CBL 24780
      SUBROUTINE ENVERT(N, A, IAdeg, AI, BI, F)
      DIMENSION A(7,7,3),AI(7,7,15),BI(7,7,15),F(27)
      IAdeg1 = IAdeg + 1
      DO 50 I = 1, N
      DO 50 J = 1, N
      DO 50 K = 1, IAdeg1
50 AI(I,J,K) = A(I,J,K)
      IBdeg = 0
      DO 10 L = 1, N
      IF (L .EQ. 1) GO TO 20
      CALL MATMPY (A,N,IAdeg,BI,N,IBdeg,AI+3,7,7)
20 IBdeg = IBdeg + IAdeg
      RL = L
      CALL TRACE(N, AI, IBdeg, RL, P)
      IF (L .EQ. N) GO TO 30
10 CALL COMPRI(N, IBdeg, AI, P, BI)
30 CONTINUE
      RETURN
      END

      SUBROUTINE SCALER (C,SCALE,M,N,NC)
      DIMENSION C(7,7,NC)
      IF(NC.LE.1) RETURN
      DO 1 I=1,M
      DO 1 J=1,N
      DO 1 K=2,NC
1 C(I,J,K)=C(I,J,K)*SCALE** (K-1)
      RETURN
      END

      SUBROUTINE EQUIL (C,M,N,NC,EQ,DDET)
      DIMENSION C(7,7,NC),EQ(M)
      DDET=1.0
      DO 1 I=1,M
      AMAX=C(1,1,1)
      DO 2 J=1,N
      DO 2 K=1,NC
2 CC=ABS(C(I,J,K))
      IF (CC.GT.AMAX) AMAX=CC
1 CONTINUE
      EQ(1)=10./AMAX
      DO 3 J=1,N
      DO 3 K=1,NC
3 C(I,J,K)=C(I,J,K)*EQ(1)
1 DDET=DDET*EQ(1)
      DDFT=DDET*(-1)**(M-1)
      RETURN
      END
      .....
      SUBROUTINE PRBM1

```

C
C PURPOSE
C TO CALCULATE ALL REAL AND COMPLEX ROOTS OF A GIVEN
C POLYNOMIAL WITH REAL COEFFICIENTS.
C
C USAGE
C CALL PRBM1 (C,IC,RR,RC,PCL,IR,IER,LIM)
C
C DESCRIPTION OF PARAMETERS
C C - INPUT VECTOR CONTAINING THE COEFFICIENTS OF THE
C GIVEN POLYNOMIAL. COEFFICIENTS ARE ORDERED FROM
C LOW TO HIGH. ON RETURN COEFFICIENTS ARE DIVIDED
C BY THE LAST NONZERO TERM.
C IC - DIMENSION OF VECTORS C, RR, RC, AND PCL.
C RR - RESULTANT VECTOR OF REAL PARTS OF THE ROOTS.
C RC - RESULTANT VECTOR OF COMPLEX PARTS OF THE ROOTS.
C PCL - RESULTANT VECTOR OF COEFFICIENTS OF THE POLYNOMIAL
C WITH CALCULATED ROOTS. COEFFICIENTS ARE ORDERED
C FROM LOW TO HIGH (SEE REMARK 4).
C IR - OUTPUT VALUE SPECIFYING THE NUMBER OF CALCULATED
C ROOTS. NORMALLY IR IS EQUAL TO IC-1.
C IER - RESULTANT ERROR PARAMETER CODED AS FOLLOWS
C IER=0 - NO ERROR.
C IER=1 - SUBROUTINE PQFB RECORDS POOR CONVERGENCE
C AT SOME QUADRATIC FACTORIZATION WITHIN
C 50 ITERATION STEPS.
C IER=2 - POLYNOMIAL IS DEGENERATE, I.E. ZERO OR
C CONSTANT,
C OR OVERFLOW IN NORMALIZATION OF GIVEN
C POLYNOMIAL.
C IER=3 - THE SUBROUTINE IS BYPASSED DUE TO
C SUCCESSIVE ZERO DIVISORS OR OVERFLOWS
C IN QUADRATIC FACTORIZATION OR DUE TO
C COMPLETELY UNSATISFACTORY ACCURACY.
C IER=-1 - CALCULATED COEFFICIENT VECTOR HAS LESS
C THAN THREE CORRECT SIGNIFICANT DIGITS.
C THIS REVEALS POOR ACCURACY OF CALCULATED
C ROOTS.
C LIM - NUMBER OF ITERATION STEPS, MAXIMAL 50.
C
C REMARKS
C (1) REAL PARTS OF THE ROOTS ARE STORED IN RR(1) UP TO RR(IR) AND CORRESPONDING COMPLEX PARTS IN RC(1) UP TO RC(IR).
C (2) ERROR MESSAGE IER=1 INDICATES POOR CONVERGENCE WITHIN 50 ITERATION STEPS AT SOME QUADRATIC FACTORIZATION PERFORMED BY SUBROUTINE PQFB.
C (3) NO ACTION BEIDES ERROR MESSAGE IER=2 IN CASE OF A ZERO OR CONSTANT POLYNOMIAL. THE SAME ERROR MESSAGE IS GIVEN IN CASE OF AN OVERFLOW IN NORMALIZATION OF GIVEN POLYNOMIAL.
C (4) ERROR MESSAGE IER=3 INDICATES SUCCESSIVE ZERO DIVISORS OR OVERFLOWS OR COMPLETELY UNSATISFACTORY ACCURACY AT ANY QUADRATIC FACTORIZATION PERFORMED BY SUBROUTINE PQFB. IN THIS CASE CALCULATION IS BYPASSED. IR RECORDS THE NUMBER OF CALCULATED ROOTS.
C PCL(1),...,PCL(J-IR) ARE THE COEFFICIENTS OF THE

C REMAINING POLYNOMIAL, WHERE J IS THE ACTUAL NUMBER OF CBL 25860
C COEFFICIENTS IN VECTOR C (NORMALY J=IC). CBL 25870
C (5) IF CALCULATED COEFFICIENT VECTOR HAS LESS THAN THREE CBL 25880
C CORRECT SIGNIFICANT DIGITS THOUGH ALL QUADRATIC CBL 25890
C FACTORIZATIONS SHOWED SATISFACTORY ACCURACY, THE ERROR CBL 25900
C MESSAGE IER=-1 IS GIVEN. CBL 25910
C (6) THE FINAL COMPARISON BETWEEN GIVEN AND CALCULATED CBL 25920
C COEFFICIENT VECTOR IS PERFORMED ONLY IF ALL ROOTS HAVE CBL 25930
C BEEN CALCULATED. IN THIS CASE THE NUMBER OF ROOTS IR IS CBL 25940
C EQUAL TO THE ACTUAL DEGREE OF THE POLYNOMIAL (NORMALY CBL 25950
C IR=IC-1). THE MAXIMAL RELATIVE ERROR OF THE COEFFICIENT CBL 25960
C VECTOR IS RECORDED IN RR(IR+1). CBL 25970
C CBL 25980
C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED CBL 25990
C SUBROUTINE PQFB QUADRATIC FACTORIZATION OF A POLYNOMIAL CBL 26000
C BY BAIRSTOW ITERATION. CBL 26010
C CBL 26020
C METHOD CBL 26030
C THE ROOTS OF THE POLYNOMIAL ARE CALCULATED BY MEANS OF CBL 26040
C SUCCESSIVE QUADRATIC FACTORIZATION PERFORMED BY BAIRSTOW CBL 26050
C ITERATION. X**2 IS USED AS INITIAL GUESS FOR THE FIRST CBL 26060
C QUADRATIC FACTOR, AND FURTHER EACH CALCULATED QUADRATIC CBL 26070
C FACTOR IS USED AS INITIAL GUESS FOR THE NEXT ONE. AFTER CBL 26080
C COMPUTATION OF ALL ROOTS THE COEFFICIENT VECTOR IS CBL 26090
C CALCULATED AND COMPARED WITH THE GIVEN ONE. CBL 26100
C FOR REFERENCE, SEE J. H. WILKINSON, THE EVALUATION OF THE CBL 26110
C ZEROS OF ILL-CONDITIONED POLYNOMIALS (PART ONE AND TWO), CBL 26120
C NUMERISCHE MATHEMATIK, VOL.1 (1959), PP.150-180. CBL 26130
C CBL 26140
C CBL 26150
C SUBROUTINE PRBM1(C,IC,RR,RC,PCL,IR,IER,LIM) CBL 26160
C CBL 26170
C CBL 26180
C CBL 26190
C DIMENSION C(1),RR(1),RC(1),PCL(1),Q(4) CBL 26200
C TEST=1.E+70 CBL 26210
C CBL 26220
C TEST ON LEADING ZERO COEFFICIENTS CBL 26230
C EPS=1.E-3 CBL 26240
C LIM=KK*LIM WHERE KK=1 OR 2 AND LIM=50. CBL 26250
C IR=IC+1 CBL 26260
1 IR=IR-1 CBL 26270
IF(IR-1)42,42,2 CBL 26280
2 IF(C(IR))3,1,3 CBL 26290
C CBL 26300
C WORK UP ZERO ROOTS AND NORMALIZE REMAINING POLYNOMIAL CBL 26310
3 IER=0 CBL 26320
J=IR CBL 26330
L=0 CBL 26340
A=C(IR) CBL 26350
DO 8 I=1, IR CBL 26360
IF(L)4,4,7 CBL 26370
4 IF(C(I))6,E,6 CBL 26380
5 RR(I)=0. CBL 26390
RC(I)=0. CBL 26400

FILE CABLE FORTRAN P1

G F L M N A N D A T A S Y S T E M S

```
POL(J)=0.  
J=J-1  
GO TO 8  
6 L=1  
IST=I  
J=0  
7 J=J+1  
C(I)=C(I)/A  
POL(J)=C(I)  
IF(POL(J).GT.TEST) GO TO 42  
8 CONTINUE  
  
C  
C START HAIRSTOW ITERATION  
Q1=0.  
Q2=0.  
9 IF(J-2)33,10,14  
  
C  
C DEGREE OF RESTPOLYNOMIAL IS EQUAL TO ONE  
10 A=POL(1)  
PR(IST)=-A  
RC(IST)=0.  
IR=IR-1  
Q2=0.  
IF(IR-1)13,13,11  
11 DO 12 I=2,IR  
Q1=Q2  
Q2=POL(I+1)  
12 POL(I)=A*Q2+Q1  
13 POL(IR+1)=A+Q2  
GO TO 34  
  
C THIS IS BRANCH TO COMPARISON OF COEFFICIENT VECTORS C AND POL  
  
C DEGREE OF RESTPOLYNOMIAL IS GREATER THAN ONE  
14 DO 22 L=1,10  
N=1  
15 Q(1)=Q1  
Q(2)=Q2  
CALL PQFB1(POL,J,Q,LIM,I)  
IF(I)16,24,23  
16 IF(Q1)1E,17,1E  
17 IF(Q2)18,21,1E  
18 GO TO (19,20,19,21),N  
19 Q1=-Q1  
N=N+1  
GO TO 15  
20 Q2=-Q2  
N=N+1  
GO TO 15  
21 Q1=1.+Q1  
22 Q2=1.-Q2  
  
C  
C ERROR EXIT DUE TO UNSATISFACTORY RESULTS OF FACTORIZATION  
IFR=3  
IR=IR-J  
RETURN
```

FILE CABLE FORTRAN PI

G F U N K A R DATA SYSTEM

C
C WORK UP RESULTS OF QUADRATIC FACTORIZATION
23 IER=1
24 Q1=Q(1)
Q2=Q(2)
C
C PERFORM DIVISION OF FACTORIZED POLYNOMIAL BY QUADRATIC FACTOR
R=0.
A=0.
I=J
25 H=-Q1*B-Q2*A+POL(I)
POL(I)=B
B=A
A=F
I=I-1
IF(I-2)26,26,25
26 POL(2)=B
POL(1)=A
C
C MULTIPLY POLYNOMIAL WITH CALCULATED FACTORS BY QUADRATIC FACTOR
L=IR-1
IF(J-L)27,27,29
27 DO 28 I=J,L
28 POL(I-1)=POL(I-1)+POL(I)*Q2+PCL(I+1)*Q1
29 POL(L)=POL(L)+POL(L+1)*Q2+Q1
POL(IR)=POL(IR)+Q2
C
C CALCULATE ROOT-PAIR FROM QUADRATIC FACTOR $x^2 + Q2*x + Q1$
H=-.5*Q2
A=F-F-Q1
B=SQRT(ABS(A))
IF(A)30,30,31
30 RR(IST)=F
RC(IST)=B
IST=IST+1
RR(IST)=H
RC(IST)=-B
GO TO 32
31 B=F+SIGN(B,H)
RR(IST)=Q1/B
RC(IST)=C.
IST=IST+1
RR(IST)=B
RC(IST)=C.
32 IST=IST+1
J=J-2
GO TO 9
C
C SHIFT BACK ELEMENTS OF POL BY 1 AND COMPARE VECTORS POL AND C
33 IR=IR-1
34 A=0.
DO 35 I=1,IR
Q1=C(I)
Q2=POL(I+1)
POL(I)=Q2
CBL 26960
CBL 26970
CBL 26980
CBL 26990
CBL 27000
CBL 27010
CBL 27020
CBL 27030
CBL 27040
CBL 27050
CBL 27060
CBL 27070
CBL 27080
CBL 27090
CBL 27100
CBL 27110
CBL 27120
CBL 27130
CBL 27140
CBL 27150
CBL 27160
CBL 27170
CBL 27180
CBL 27190
CBL 27200
CBL 27210
CBL 27220
CBL 27230
CBL 27240
CBL 27250
CBL 27260
CBL 27270
CBL 27280
CBL 27290
CBL 27300
CBL 27310
CBL 27320
CBL 27330
CBL 27340
CBL 27350
CBL 27360
CBL 27370
CBL 27380
CBL 27390
CBL 27400
CBL 27410
CBL 27420
CBL 27430
CBL 27440
CBL 27450
CBL 27460
CBL 27470
CBL 27480
CBL 27490
CBL 27500

```

      IF(Q1)35,36,35                                CBL 27510
  35 Q2=(Q1-Q2)/Q1                                CBL 27520
  36 Q2=ABS(Q2)                                    CBL 27530
  37 IF(Q2-A)38,38,37                                CBL 27540
  38 A=Q2                                         CBL 27550
  39 CONTINUE                                       CBL 27560
  40 I=IR+1                                         CBL 27570
  41 POL(I)=1.                                      CBL 27580
  42 RR(I)=A                                       CBL 27590
  43 RC(I)=0.                                       CBL 27600
  44 IF(IER)39,39,41                                CBL 27610
  39 IF(A-EPS)41,41,40                                CBL 27620
  40 IER=-1                                         CBL 27630
  41 RETURN                                         CBL 27640
  42 IFR=2                                           CBL 27650
  43 IR=0                                            CBL 27660
  44 RETURN                                         CBL 27670
  45 NORMALIZATION                                  CBL 27680
  46 END                                             CBL 27690
  47 .....                                           CBL 27700
  48 .....                                           CBL 27710
  49 .....                                           CBL 27720
  50 .....                                           CBL 27730
  51 .....                                           CBL 27740
  52 .....                                           CBL 27750
  53 .....                                           CBL 27760
  54 .....                                           CBL 27770
  55 .....                                           CBL 27780
  56 .....                                           CBL 27790
  57 .....                                           CBL 27800
  58 .....                                           CBL 27810
  59 .....                                           CBL 27820
  60 .....                                           CBL 27830
  61 .....                                           CBL 27840
  62 .....                                           CBL 27850
  63 .....                                           CBL 27860
  64 .....                                           CBL 27870
  65 .....                                           CBL 27880
  66 .....                                           CBL 27890
  67 .....                                           CBL 27900
  68 .....                                           CBL 27910
  69 .....                                           CBL 27920
  70 .....                                           CBL 27930
  71 .....                                           CBL 27940
  72 .....                                           CBL 27950
  73 .....                                           CBL 27960
  74 .....                                           CBL 27970
  75 .....                                           CBL 27980
  76 .....                                           CBL 27990
  77 .....                                           CBL 28000
  78 .....                                           CBL 28010
  79 .....                                           CBL 28020
  80 .....                                           CBL 28030
  81 .....                                           CBL 28040
  82 .....                                           CBL 28050

```

C

C WARNING DUE TO POOR ACCURACY OF CALCULATED COEFFICIENT VECTOR

C 40 IER=-1

C 41 RETURN

C

C ERROR EXIT DUE TO DEGENERATE POLYNOMIAL OR OVERFLOW IN

C NORMALIZATION

C 42 IFR=2

C IR=0

C RETURN

C END

C

C

C

C SUBROUTINE PQFB1

C

C PURPOSE

C TO FIND AN APPROXIMATION Q(X)=Q1+C2*X*X TO A QUADRATIC

C FACTOR OF A GIVEN POLYNOMIAL P(X) WITH REAL COEFFICIENTS.

C

C USAGE

C CALL PQFB1(C,IC,Q,LIM,IER)

C

C DESCRIPTION OF PARAMETERS

C C - INPUT VECTOR CONTAINING THE COEFFICIENTS OF P(X) -

C C(1) IS THE CONSTANT TERM (DIMENSION IC)

C IC - DIMENSION OF C

C Q - VECTOR OF DIMENSION 4 - ON INPUT C(1) AND Q(2) MUST

C CONTAIN INITIAL GUESSES FOR Q1 AND Q2 - ON RETURN Q(1) CBL 27920

C AND Q(2) CONTAIN THE REFINED COEFFICIENTS Q1 AND Q2 OF CBL 27930

C P(X), WHILE Q(3) AND Q(4) CONTAIN THE COEFFICIENTS A CBL 27940

C AND B OF A+B*X, WHICH IS THE REMAINDER OF THE QUOTIENT CBL 27950

C OF P(X) BY Q(X)

C LIM - INPUT VALUE SPECIFYING THE MAXIMUM NUMBER OF

C ITERATIONS TO BE PERFORMED

C IER - RESULTING ERROR PARAMETER (SEE REMARKS)

C IER= 0 - NO ERROR

C IER= 1 - NO CONVERGENCE WITHIN LIM ITERATIONS

C IER=-1 - THE POLYNOMIAL P(X) IS CONSTANT OR UNDEFINED CBL 28020

C - OR OVERFLOW OCCURRED IN NORMALIZING P(X) CBL 28030

C IER=-2 - THE POLYNOMIAL P(X) IS OF DEGREE 1 CBL 28040

C IER=-3 - NO FURTHER REFINEMENT OF THE APPROXIMATION TO CBL 28050

A QUADRATIC FACTOR IS FEASIBLE, DUE TO EITHER CBL 28060
 DIVISION BY 0, OVERFLOW OF AN INITIAL GUESS CBL 28070
 THAT IS NOT SUFFICIENTLY CLOSE TO A FACTOR OF CBL 28080
 P(X) CBL 28090
 CBL 28100
 CBL 28110

REMARKS

- (1) IF IER=-1 THERE IS NO COMPUTATION OTHER THAN THE POSSIBLE NORMALIZATION OF C. CBL 28120
 CBL 28130
- (2) IF IER=-2 THERE IS NO COMPUTATION OTHER THAN THE NORMALIZATION OF C. CBL 28140
 CBL 28150
- (3) IF IER =-3 IT IS SUGGESTED THAT A NEW INITIAL GUESS BE CBL 28160
 MADE FOR A QUADRATIC FACTOR. C, HOWEVER, WILL CONTAIN CBL 28170
 THE VALUES ASSOCIATED WITH THE ITERATION THAT YIELDED CBL 28180
 THE SMALLEST NORM OF THE MODIFIED LINEAR REMAINDER. CBL 28190
- (4) IF IER=1, THEN, ALTHOUGH THE NUMBER OF ITERATIONS LIM CBL 28200
 WAS TOO SMALL TO INDICATE CONVERGENCE, NO OTHER PROBLEMS HAVE BEEN DETECTED, AND C WILL CONTAIN THE VALUES CBL 28210
 ASSOCIATED WITH THE ITERATION THAT YIELDED THE SMALLEST CBL 28220
 NORM OF THE MODIFIED LINEAR REMAINDER. CBL 28230
 CBL 28240
- (5) FOR COMPLETE DETAIL SEE THE DOCUMENTATION FOR CBL 28250
 SUBROUTINES PQFB AND DPQFB. CBL 28260
 CBL 28270

SUBROUTINES AND FUNCTION SUBPROGRAMS RECLINED

NONE

METHOD

COMPUTATION IS BASED ON BAIRSTOW'S ITERATIVE METHOD. (SEE CBL 28320
 WILKINSON, J.H., THE EVALUATION OF THE ZEROS OF ILL-CONDITIONED CBL 28330
 POLYNOMIALS (PART ONE AND TWO), NUMERISCHE MATHEMATIK, VOL. 1 (1959), CBL 28340
 PP. 150-180, (F. HILDEBRAND, F.B., CBL 28350
 INTRODUCTION TO NUMERICAL ANALYSIS, MC GRAW-HILL, NEW YORK/TORONTO/LONDON, CBL 28360
 1956, PP. 472-476.) CBL 28370
 CBL 28380

***** CBL 28390
 ***** CBL 28400

SUBROUTINE PQFB1(C, IC, Q, LIM, IER)

DIMENSION C(4), Q(4)

TEST ON LEADING ZERO COEFFICIENTS

```

IER=0
TEST=1.E+7C
J=IC+1
1 J=J-1
  IF(J-1)40,4C,2
2 IF(C(J))3,1,3

```

NORMALIZATION OF REMAINING COEFFICIENTS

```

3 A=C(J)
  IF(A-1.)4.6,4
4 DO 5 I=1,J
  C(I)=C(I)/A
  IF(C(I).GT.TEST) GO TO 40
5 CONTINUE

```

FILE CABLE FORTRAN P1

G F U N N A R D A T A S Y S T E M

C
C TEST ON NECESSITY OF BAIRSTOW ITERATION
— 6 IF(J-3)41,38,7
C
C PREPARE BAIRSTOW ITERATION
7 EPS = 1.E-4
EPS1= 1.E-2
L=0
LL=0
Q1=Q(1)
Q2=Q(2)
QQ 1=0.
QQ 2=0.
AA=C(1)
BB=C(2)
CR=ABS(AA)
CA=ABS(BB)
IF(CB-CA)8,9,10
8 CC=CF+CB
CB=CB/CA
CA=1.
GO TO 11
9 CC=CA+CA
CA=1.
CB=1.
GO TO 11
10 CC=CA+CA
CA=CA/CB
CB=1.
11 CD=CC*.1
C
C START BAIRSTOW ITERATION
C PRFPARE NESTED MULTIPLICATION
12 A=0.
R=A
A1=A
B1=A
I=J
QQQ1=0 1
QQQ2=0 2
DQ 1=FH
DQ 2=F
C
C START NESTED MLL TIPLICATION
13 H=-Q1*B-Q2*A+C(I)
IF(F.GT.TEST) GO TO 42
B=A
A=F
I=I-1
IF(I-1)18,15,16
15 H=C.
16 H=-Q1*B1-Q2*A1+H
IF(F.GT.TEST) GO TO 42
C1=B1
B1=A1

CBL 28610
CBL 28620
CBL 28630
CBL 28640
CBL 28650
CBL 28660
CBL 28670
CBL 28680
CBL 28690
CBL 28700
CBL 28710
CBL 28720
CBL 28730
CBL 28740
CBL 28750
CBL 28760
CBL 28770
CBL 28780
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CBL 29070
CBL 29080
CBL 29090
CBL 29100
CBL 29110
CBL 29120
CBL 29130
CBL 29140
CBL 29150

FILE CAIN.F FORTRAN P1

G F U N N A N D A T A S Y S T E M

```
A1=F          CBL 29160
GO TO 13      CBL 29170
C           END OF NESTED MULTIPLICATION
C
C           TEST ON SATISFACTORY ACCURACY
18 H=CA*ABS(A)+CB*ABS(B)      CBL 29180
    IF(LL)19,15,39            CBL 29190
19 L=L+1              CBL 29200
    IF(ABS(A)-EPS*ABS(C(1)))20,20,21  CBL 29210
20 IF(ABS(B)-EPS*ABS(C(2)))39,39,21  CBL 29220
C
C           TEST ON LINEAR REMAINDER OF MINIMUM NCFN
21 IF(H-CC)22,22,23      CBL 29230
22 AA=A      CBL 29240
    BB=B      CBL 29250
    CC=C      CBL 29260
    QQ 1=Q1      CBL 29270
    QQ 2=Q2      CBL 29280
C
C           TEST ON LAST ITERATION STEP
23 IF(L-LIM)28,28,24      CBL 29290
C
C           TEST ON RESTART OF BAIRSTOW ITERATION WITH ZERO INITIAL GUESS
24 IF(H-CD)43,43,25      CBL 29300
25 IF(Q(1))27,26,27      CBL 29310
26 IF(Q(2))27,42,27      CBL 29320
27 Q( 1)=0.      CBL 29330
    Q( 2)=0.      CBL 29340
    GO TO 7      CBL 29350
C
C           PERFORM ITERATION STEP
28 H1=ABS(A1)      CBL 29360
    H2=ABS(B1)      CBL 29370
    IF(H1-H2)45,46,46  CBL 29380
45 H1=ABS(C1)      CBL 29390
    IF(H1-H2)47,48,48  CBL 29400
46 H2=ABS(C1)      CBL 29410
    IF(H1-H2)48,49,49  CBL 29420
47 HH=ABS(R1)      CBL 29430
    GO TO 50      CBL 29440
48 HH=ABS(C1)      CBL 29450
    GO TO 50      CBL 29460
49 HH=ABS(A1)      CBL 29470
50 IF(HH)42,42,29      CBL 29480
29 A1=A1//F      CBL 29490
    B1=B1//F      CBL 29500
    C1=C1//F      CBL 29510
    H=A1*C1-B1*R1  CBL 29520
    IF(H)30,42,30  CBL 29530
30 A=A//F      CBL 29540
    B=B//F      CBL 29550
    HH=(B*A1-A*B1)/H  CBL 29560
    H=(A*C1-B*B1)/H  CBL 29570
    Q1=Q1+F      CBL 29580
    Q2=Q2+F      CBL 29590
CBL 29600
CBL 29610
CBL 29620
CBL 29630
CBL 29640
CBL 29650
CBL 29660
CBL 29670
CBL 29680
CBL 29690
CBL 29700
```

```

C      END OF ITERATION STEP                                CBL 29710
C
C      TEST ON SATISFACTORY RELATIVE ERROR OF ITERATED VALUES
C      IF(ABS(HH)-EPS*ABS(Q1))31,31,33                      CBL 29720
C      31 IF(ABS(H)-EPS*ABS(Q2))32,32,33                  CBL 29730
C      32 LL=1                                              CBL 29740
C      GO TO 12                                            CBL 29750
C
C      TEST ON DECREASING RELATIVE ERRORS
C      33 IF(L-1)12,12,34                                    CBL 29760
C      34 IF(ABS(HH)-EPS1*ABS(Q1))35,35,12                 CBL 29770
C      35 IF(ABS(H)-EPS1*ABS(Q2))36,36,12                 CBL 29780
C      36 IF(ARS(QQQ1*HH)-ARS(Q1*DQ1))37,44,44          CBL 29790
C      37 IF(ARS(QQQ2*H)-ARS(Q2*DQ2))12,44,44          CBL 29800
C      END OF BAIRSTOW ITERATION                           CBL 29810
C
C      EXIT IN CASE OF QUADRATIC POLYNOMIAL
C      38 Q( 1)=C( 1)                                     CBL 29820
C      Q( 2)=C( 2)                                     CBL 29830
C      Q( 3)=0.                                         CBL 29840
C      Q( 4)=0.                                         CBL 29850
C      RETURN                                           CBL 29860
C
C      EXIT IN CASE OF SUFFICIENT ACCURACY
C      39 Q( 1)=Q1                                       CBL 29870
C      Q( 2)=Q2                                       CBL 29880
C      Q( 3)=A                                         CBL 29890
C      Q( 4)=B                                         CBL 29900
C      RETURN                                           CBL 29910
C
C      ERROR EXIT IN CASE OF ZERO OR CONSTANT POLYNOMIAL
C      40 IER=-1                                       CBL 29920
C      RETURN                                           CBL 29930
C
C      ERROR EXIT IN CASE OF LINEAR POLYNOMIAL
C      41 IER=-2                                       CBL 29940
C      RETURN                                           CBL 29950
C
C      ERROR EXIT IN CASE OF NONREFINED QUADRATIC FACTOR
C      42 IER=-3                                       CBL 29960
C      GO TO 44                                         CBL 29970
C
C      ERROR EXIT IN CASE OF UNSATISFACTORY ACCURACY
C      43 IER=1                                         CBL 29980
C      44 Q( 1)=QQ1                                      CBL 29990
C      Q( 2)=QQ2                                      CBL 30000
C      Q( 3)=AA                                       CBL 30010
C      Q( 4)=BB                                       CBL 30020
C      RETURN                                           CBL 30030
C
C      END OF PROGRAM                                     CBL 30040

```